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A GLANCE AT THE PHYLETIC BACKGROUND OF GENETIC PSYCHOLOGY.

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The background of the genetic aspect of everything is time, which is as indefinable and as primordial as its counterpart, space. There is nothing really actual or conceivably possible that is either spaceless or timeless, and to try to think anything so is stultification. Force, atoms, electrons, souls, thoughts, feelings, and all other activities have position, extent and duration, though we may not be able to measure them. Nothing can be outside of, before, after or independent of either time or space. If the universe were resolved into ether or nothingness, or to die Clausius's heat-death, or to vanish by the slow evaporation of all its solid matters, these would remain unaffected, for they are independent of their content as they are of knowledge. Both are continuous and unbroken, vaster than any imaginable bounds, yet indefinitely divisible. Or if infinity mean only that process is endless, there is nothing transfinitive in the sense of the older theories. They have been thought to be empirical and *a priori*, objective and subjective, have been ascribed to sense, reason, memory, will and special and general feelings, and faculties have been invented as their organs,[1] they are, in fact, more or less involved in every psychic activity, animal or human, concrete or abstract, but their a priority is not logical but genetic, for they are the

[1] For general history of views upon the subject, see Joh. Jul. Baumann Die Lehren von Raum, Zeit. u. Mathematik in der neueren Philosophie, 2 Bde., G. Reimer, Berlin, 1868; also H. Nichols: The Psychology of Time. Clark Univ. Thesis. Henry Holt & Co., New York, 1891.

only truly metaphysical objects. Their universality is not because they are ineluctable factors of thought, but conversely they are the latter because they are the former. Both have their poetry, their religion, also their illusions, phobias and panics. Instead of being the complex mysteries which epistemology and even the usually clear headed Wundt[1] makes them, nothing else is so simple or homogeneous. It is for this reason that knowledge becomes scientific just in proportion as it is exactly defined in their terms, because they are the best known of all things.

To teach them to be mere subjective forms, existent only for us in the sense of Kant,[2] which is oriental in spirit and scholastic in method, is, at the same time, the acme of man's anthropomorphism and conceit of his place in the universe, which in ancient Greece would invite the nemesis of the gods, and is today a crime without a name against the soul of youth just at the time when the passion for certain and objective reality is strongest and when vulnerability to such sophistication is greatest. The objectivity of time and space begins in the very ectoderm from which the nervous system is an infoldment, and to make even the present, which seems the most real part of both, merely specious, despite the fact that to focus everything remote into the magic here and now, is the best definition we have of genius and sanity, is to belie the whole phyletic experience of the soul which acquired through innumerable generations all that is innate in the individual and betrays a subtle mark of incipient mental decay. With the growth of mathematics and a dozen other sciences, our conceptions of time and space, both small and great, have in late years been extended by leaps and bounds, so that the old philosophical ideas of them are far transcended, while psychology has developed rich, fruitful and complex special fields for each. They remain indefinable because by them and by mass all things else are explained.[3]

Time is, at bottom, duration and motion is its measure. Though we can conceive no beginning or end, it is not, therefore, necessarily infinite or eternal, and to ask whether every flitting instant which takes from the future and adds to the past makes the one shorter and the other longer is a vain query. Time contains every causal series that exists at once and

[1] W. Wundt: Die Unendlichkeit der Welt. Essays, 2 te Aufl., Engelmann 1906, pp. 136-184.

[2] Henerle (Die Theorie der Materie) sees in matter only a necessary hypothesis and in the new theories of it only what might have been deduced from the old atomism.

[3] See general conception of space. Adolescence, Vol. 2, pp. 159 and 540. D. Appleton & Co., New York, 1904.

might contain innumerable others. Every effect follows its cause in time, short though the interval be. All histories are forms of construing it. It is irreversible and would go on in the same direction if at the end of some great Platonic era the horology of the temporal order and sequence of all things were inverted and the old grew young and evolution became involution. It would have no gap if all thought and all change stopped for a time and then went on again. It is neither a construction nor an entity. It is not all form or content, concrete or abstract. We cannot affirm that it is finite or infinite, but it defies and transcends all these distinctions as it baffles every definition, but just is, a sun-clear fact, the *primum movens* of all genetic psychology. A recent subtle philosopher[1] makes it a chronic disturber of speculative systems, ever creeping in and making all unstable, and defines time as a negation, as "abstract or dynamic non-being," and the latter as "the genus within which time is the species." If we understand this weird conclusion it is the most flagrant metaphysical perversion of the plain truth about time in a long sad history of them. We must, on the contrary, regard the highest and most complete knowledge or science of anything as the full and accurate description and explanation of all its developmental stages in their temporal sequence. When we can answer the question what occurs at each step, and why, there is no more left to know. Evolution thus, gives a new ideal to, and a higher standard of, noetic values which transcend many lower types, such as definition by genus and difference, classification, deduction from categories, analysis that is introspective, but without perspective. The subordination of these older static methods is in the interests of positive and progressive truth.

Our life is brief and so absorbed with what is near that we are mentally myopic for time. This almost constitutes a new fallacy or idol which impels us to explain all things by their nearest cause, partial though it be, as if this were a law of logical parsimony instead of mere sluggish inertia. Just as it was easier to say that fossil shells on the Alps were dropped there by Crusaders, who we know did carry some as charms, than it was to develop the science of palæontology, so it is simpler to say that the morbid fears of children are due to early frights, and their anger, pity, water, tree and sky-psychoses to their own infant experience, to the exclusion of palæo-atavistic influences. Some regard time as if it were a limited bank deposit so that our economy must be severe and we must admit only grudgingly every new demand lest our account be overdrawn.

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[1] J. E. Boodin: Time and Reality. Monograph Supplement of the Psychological Review, October, 1904. Vol. VI, No. 3, 119 p.

Difficulties in the expansion of our ideas of space, though somewhat analogous, were earlier and far more easily overcome. The provincial mind is too prone to regard product rather than process, and finds it hard to realize that everything is hoary with age, that all things we know are in flux, are terminals of a vast past and germinals of a vast future, and that the highest science is the law of change. It is an inveterate habit of thought inherited from ages of superstition that makes us prone, when confronted by seeming breaks or chasms in nature, to fly to some hypothesis of supernal intervention or creationism. The catastrophism psychosis, chronically to prefer unproven revolution to yet unverified evolution, is only a moderate improvement upon miracles. Some appear to feel that they hold a brief either for religion or pedagogy to minimize time, and so urge with almost partisan zeal that the period of authentic history and culture was brief, that man was not tertiary or life pre-Huronian, that the world is really new, etc., as if chronological concepts were in danger of hypertrophy, the sea room of thought restricted, or as if, like valley dwellers, they craved a limited horizon. The opposite tendency is now more scientific, truer, psychologically and pedagogically better, so that if in doubt, and assumption is needful, we should choose the longer and not the shorter time, not merely to indulge the momentum of evolutionary thought, but as an aid to clearer insight and to larger views of the universe.

If all the bodies of our solar system were resolved into nebulæ and uniformly diffused through the sphere of which Neptune's orbit would be a circumference, or if all the matter of the 1000 million suns and yet more dark bodies in our sky were thus diffused, they would hardly dim the passage of the light of a faint star, so infinitesimal is matter compared to the space through which it is distributed. And yet some geologists are now inferring from the structure of the earth, and some astronomers from the composition of meteorites and other heavenly bodies, that, slowly as systems were evolved and rare as collisions are, all celestial bodies have grown up and been resolved back to all stages of chaos by collisions of every kind, degree and angle, perhaps many times, and that the most constant orbits are products of selection of safest paths, so that the entire history of our earth from cosmic gas serves only as unity in computing that of the universe. In the solar system we hear of an ancestral sun that preceded ours, and thus meteors, hundreds of which strike our earth daily, though in one billion years they would add but one inch to its surface they have, nevertheless, in one form of the planetesimal theory, built it up. Indeed, the structure of some of these wandering bodies suggests a destructive and reconstructive history as indubitable as

that of metamorphic rocks. On this view the present visible universe is only one of the countless forms which its substance and energy have taken on, and the oldest objects in any corner of it are novelties to a mind vast and ancient enough to grasp the larger history of its eternal flux. Still more perhaps in the abyss of time, all possible combinations of the innumerable elements of the cosmos may have occurred. Of course all this is utterly unproven, but if we need time beyond the power of the higher arithmetic to compute, we may take it freely.

Hutton[1] thought that terrestrial history showed no trace of a beginning and no prospect of an end, and Lyell[2] despised cosmogony and would have geology accept nothing from astronomy or physics. Only with the rise of evolutionary thought did the problem of the age of the world acquire vital interest.

Suess[3] says that while we can use interstellar distances as unities to aid us in conceiving astronomic spaces, we have no apparatus for geologic time. The age that separates us from common fossils, or perhaps two of them from each other, is, like those celestial bodies, without parallax, which inform us of their physical constitution by their spectrum, but furnish no clue of their distance.

George Howard Darwin[4] holds that the moon broke away from the earth at least 56,000,000 years ago, and, perhaps, much earlier, and that when it did so, charged with steam and gas, pressure diminished as it receded and it fairly boiled with explosions and volcanoes. This, of course, constituted one great epoch in the history of our globe. A second "consistentior status" was when the earth grew solid at a surface temperature of 1200 C°, which Lord Kelvin[5] placed between 20 and 40,000,000 years ago. The next critical period was when the temperature fell to 370 C° and steam became water, a stage which Joly[6] puts between 80 and 90,000,000 years ago. Geikie[7] would be contented with the 100,000,000 years for the whole process. Although the interior of the earth was well on to

[1] James Hutton: The Theory of the Earth. Trans. of the Royal Soc. of Edinburgh. Edinburgh, 1785.

[2] Sir Chas. Lyell: Geological Evidence of the Antiquity of Man. J. Murray, London, 1873.

[3] Edward Suess: The Face of the Earth, tr. by Hertha B. C. Sollas. Clarendon Press, Oxford, 1904-1906. Vol. II, pp. 5, 56.

[4] The Evolution of Satellites. Smithsonian Inst. An. Rep., 1897. Govt. Printing Office, Washington, 1898.

[5] William Thomson Kelvin: The Age of the Earth as an Abode fitted for Life. Smithsonian Inst. Ann. Rep., 1897, pp. 337-357. Washington, 1898.

[6] John Joly: An Estimate of the Geological Age of the Earth. Smithsonian Inst. Ann. Rep., 1899, pp. 247-288. Washington, 1901.

[7] Sir Archibald Geikie: Geological Change and Time. Smithsonian Ann. Rep., 1892, pp. 111-131. Washington, 1893.

solidification, it slowly yielded to great pressure like Barus's diabase, so that as the water sought and found the lowest level the ocean base sank still more and the land parts of the surface were proportionately raised. If with Sollas we assume the total maximums sedimentary deposits to be 50 miles thick, man now lives at the top of 34 miles of vertebrate fossils. Sollas[1] seeks from very many different data on which estimation can be calculated to assign the term of years to each geological age, assuming all the strata together to have a total thickness of 265,000 feet, and the rate of accumulation to be a foot per century, his total time is 26,500,000 years.

To come down to recent ages, estimates of time since life first appeared on earth have been often made by astronomers, physicists, geologists and palæontologists. The bases for induction in these fields differ and hence the results are very divergent, ranging from a few score thousand to hundreds of millions of years. Very different and quite as difficult and conjectural are the attempts often made by geologists to assign absolute or even relative duration to the different geological ages. H. Schmidt and Haeckel present the relation which they think occupied by each of the five geologic evolutionary periods by taking one hundred million years as the age of life and reducing it to one creation day of twenty-four hours. In this case the archæozoic period, occupying 52 million years, would be represented by 12 h. 30 m.; the palæozoic period, to which a duration of 34 million years is assigned, would be 8 h. 7 m.; the mesozoic age (11 million years) would equal 2 h. 38 m.; the cenozoic (3 million years) equal 43 m.; the anthropozoic period (140 thousand years) would equal 2 m.; the historic period (6 thousand years) 5 s.; the Christian era (2 thousand years) between 2 and 3 s.[2] Our individual life is so short that several generations of men would have to summate their exact determinations to prove that the minute hand of a clock, measuring thus the cosmic day, moved at all. The conclusion that it was not stationary would seem dangerous and fantastic to ephemera whose lives endured only a second, however intelligent they might be.

A pupil of Haeckel[3] on a somewhat different basis has actually ventured to estimate the number of generations since vertebrate life began. He begins by assuming that 250 generations at 20 years each would carry us back to 3000 B. C. The *pithecanthropus* is thought by some to have lived near the

[1] William J. Sollas: The Age of the Earth and other geographical studies. T. F. Unwin, London, 1905.

[2] See Ernst Haeckel's Last Words on Evolution. 2nd ed. A. and C. Black, London, 1899. Tr. from the 2nd ed. by Joseph McCabe.

[3] Ernst Haeckel: The Last Link. Appendix by Hans Gadow. A. Owen & Co., London, 1906. p. 120.

beginning of our last glacial epoch. If we place this 270,000 years ago and assume that this forbear of man attained puberty at 16 or 20, then some 17,000 generations would lie between him and the lowest human tribes. According to Croll[1] and Wallace, 850,000 years take us into the Miocene, with the *pliopithecus* and the *dryopithecus*. If they lived, then, 600,000 years before the *pithecanthropus* and were pubescent at ten, we cannot get less than 60,000 generations. From the apes to the lowest lemurs in the lower Eocene, assuming five years for puberty, we need 420,000 generations. If we go back to the *prototheria*, the earliest known mammals in the Triassic, we must add the whole of the Jural and Cretaceous stage, or in all 5,500,000 years, and assuming three years per generation we get 1,800,000 of these. The whole stretch from the lowest fish to man would be thus resolved into more than five million generations. each of which would mean only a small step. If we admit 17,000 generations between the man of to-day and the *pithecanthropus*, the change in each generation would be too slight to perceive or conceive. So in the change from the fish to the amphibian, if there are one million stages, the marvel rather is that so many generations should be needed to bring about the result. The stretch of time from the lowest fish to the beginning of life is probably vastly greater and the generations certainly succeeded each other far more rapidly.

Taking all the strata where they are thickest, we have a total vertical depth of perhaps twelve to fifteen miles above the simplest Silurian vertebrates, and below this stretch two Palæozoic and five Proterozoic ages and the Archæan complex, together probably quite as thick. Chamberlain and Salisbury[2] think that on the new accretion hypothesis "the real beginning of life on the earth greatly antedated even the oldest accessible formations, so that fossil evidence will never solve the problem of the origin of life." Still these authors prefer the term "archeozoic" to "archean," not because they believe in any form of the Eozoon hypothesis of traces of life in the Laurentian, which in the years 1863-94 was so hotly debated,[3] but because convinced that although metamorphism and other changes have obliterated every trace of it, life originated during this age. Of the geological record as a whole, Darwin said, "I look at the geological record as a history of the world im-

[1] James Croll: Stellar Evolution and its Relations to Time. D. Appleton & Co., New York, 1889.

[2] See T. C. Chamberlain and R. D. Salisbury: Geology. H. Holt & Co., New York, 1906. Vol. 2, pp. 160 and 276.

[3] See G. P. Merrill: Contributions to the History of American Geology. U. S. National Museum Rep., 1904, Part II, Chap. IX, p. 635. Washington, 1906.

perfectly kept and written in a changing dialect. Of this history we possess the last volume alone, relating to only two or three countries. Of this volume only here and there a short chapter has been preserved, and of each page only here and there a few lines. Each word of the slowly changing language, more or less different in successive chapters, may represent the forms of life which are entombed in our consecutive formations and which falsely appear to us to have been abruptly introduced. On this view the difficulties above discussed are greatly diminished or even disappear."[1] This opinion and Darwin's avowed agnosticism concerning the origin of life seem to Haeckel faint-hearted, and in view of the new light which phylogeny and ontogeny now shed upon each other, Darwin would perhaps have modified both views to-day.

The simplest and most generalized types of life doubtless came first, but we can only conjecture its forms before the hard parts, preserved in fossils, arose. Even the trilobites, which abounded in the Cambrian, show marked developmental stages which must have recapitulated a long phyletic evolution of the species. From the very oldest and simplest petrified forms of life to uni-cellular organisms, is a long and intricate way, but now richly set in scene by both classification and embryology. Modern biologists are so infatuated with the marvels of the cell and its parts that they have neglected the stages by which the simplest bit of structureless chromacea or moneron-like bit of protoplasm evolved into the cell. The origin of the former, which is true archigony, is still another problem occupying a vast period of which we know still less.

When we launch out from the farthest shore of microscopic visibility the vast uncharted ocean of the infinitely little stretches before us. The strongest microscope can hardly see the 100-thousandth of an inch, yet a molecule of hydrogen, consisting of two atoms, has a diameter of about one 250,000-millionth of an inch. About one thousand atoms is now the estimate in a highly organized vital molecule, yet we know very definitely that it takes about a thousand electrons to compose a single atom of hydrogen. The green glow inside an airless Crookes's tube, which is due to incandescence set up by a stream of electrons which may be deflected by a magnet as if it were a piece of iron, is caused by corpuscles which can be counted and their charge measured. The rate of leakage of charged bodies surrounded by gases which varies with their pressure, temperature, with light and moisture, have given phenomena which have led within the last few years to epoch-making results con-

[1] Charles Darwin: Origin of Species. 6th edition, D. Appleton & Co., New York, 1904. Vol. 2, p. 88.

cerning the ultimate constitution of matter.[1] The corpuscle and the charge it carries are each known only through the other. The electron is in some sense a mental image, and while it may be a strain or a whirl in the ether, the conservative view is that the corpuscular theory is favored and that Ostwald's energetics, the way to which was paved by Willard Gibbs's[2] views of energy and entropy, are very extreme. The recent studies of radium mark perhaps, the climax of human ingenuity in research. Like every other, the radium atom consists of a whirling mass of particles, some charged with positive and others with negative electricity. From this, probably on account of centrifugal force, some of these charged particles fly off with intense velocity. In passing through a gas they dash to pieces such of its component molecules as lie in their line of flight. So great is the atomic weight and the initial energy of each projectile that it can destroy some hundred thousand molecules before its velocity is reduced 40 per cent. Thereafter its power to break up or ionize the gas molecules declines rapidly. At least seven transformations of the original atom have been traced from radium A to F, and the close relations of these forms of radium to uranium, thorium and perhaps to lead, suggest the transmutation of matter. The loss of each particle causes a change in the properties of what is left behind, which differ greatly as do the different rays, the velocities of which are very distinct, though nearly constant for the same set. When they cause phosphorescence, they seem to do so only by re-enforcing the pre-existing molecular activity of the elements in the substance itself. Aggregates or clusters of these electrified corpuscles, absolutely identical in themselves, probably built up the more than fourscore chemical elements by variations in their number and arrangement—that is, they are *materia prima*. Thus light, heat, electricity, perhaps gravity and chemical affinity are forms of radio-activity, and volcanic force and even life itself are thought by some to be due to it. In the beginning was radium.

It is little wonder that so much energy with so little matter should give an impulse to dynamism, but the saner thought is that these units are more than centres of force and that, small as they are, they have a sub-stratum or core of solid matter. At least they act very like tangible bodies, moving in straight lines, if not deflected, and if they are so, the radii of their curves

[1] See J. J. Thompson: Conduction of Electricity through Gases. Cambridge University Press, 1903. A. Righi: The Modern Theory of Physical Phenomena, Macmillan, 1905. E. Rutherford: Radio-Activity. Cambridge University Press, 2nd ed., 1905.

[2] J. Willard Gibbs: Thermodynamische Studien aus dem Englisch übers von W. Ostwald. Engelmann, Leipzig, 1892.

can be calculated by the same formulæ as apply to the movements of the heavenly bodies. When they are arrested their energy is transformed into heat exactly as when a hammer strikes an anvil, and if they penetrate an atom they lose energy at a rate proportional to the square root of the atom's weight. Still these epoch-making discoveries do make us feel that the world is intensely alive or that its inorganic basis is no less but perhaps more vividly active than life itself, so that if now the soul were thought material it would seem less degraded by its origin, and its resolution into such a sub-stratum would be less repugnant. Even therapeutics has realized new relations between these forms of physical energy and life, and theories of energetics do not oppose but favor the psychic interpretation of the world. All these processes preceded and will outlast life. They are valid in every part of the universe so that their beginning is inscrutable.

Among the chemical elements, carbon, which predominates in nearly every part of plant and animal life, is marked by the number and variety of its compounds. Of these sixty thousand have already been isolated and studied, and yet, although Shenstone[1] estimates that it makes up about half of modern chemistry, the science of this element is still in its infancy. Its fecundity is seen by the fact that it has been estimated that no less than 802 tridecanes may perhaps exist, each of which would have distinct properties and yet could not be distinguished by chemical analysis the one from the other, since each has the same proportions of carbon and hydrogen and the same chemical formula. When it is added that but very few of these 802 substances are found among the sixty thousand compounds known, even the "marvels of radium pale before the possibilities that lie hidden in a handful of soot or charcoal," and we can, perhaps, understand the inspiration of the hundreds of men who for the last fourscore years have devoted their lives to the study of this element alone. The clue to this labyrinth was furnished by isomerism, which designates those cases where several distinct compounds arise from uniting the same elements in the same proportions so that properties of compounds do not depend on the nature and number of atoms in their molecules alone, but also upon the way in which they are arranged. Now there are hundreds of isomerisms and the existence and the properties of undiscovered compounds can often be predicted with a degree of accuracy hardly inferior to that which enabled Mendeléeff by his periodic law to predict

[1] W. A. Shenstone. New Physics and Chemistry. Smith, London, 1906.

the existence and foretell the properties of gallium and germanium.[1]

Another line of work which has loosened the hard-trod soil about the problems of life and mind consists in the exploration of close analogues of vital phenomena in inanimate things. Poets and philosophers have always thought there was a soul in things. Kepler was an animist and thought that the motive force of the planets was their soul. To him, almost as to the ancient hylozoists, the globe was a great animal, sensitive to astral influences, frightened into hurricanes and earthquakes by the approach of other planets. Leibnitz' continuity theory held that there was no inorganic kingdom and nothing quite dead, but a perfect and unbroken continuity, so that every, even a material, monad had a rudiment of both life and soul. Boscowich[2] did not refuse to his immaterial and infinitely small points a kind of low vitality. The alchemists and Hermetic philosophers went yet further. In point of fact, too, everything in nature works. Some rocks and precious stones are spoken of as more vital than others. A metallic rod stretched shows eventually a weak point where it would break, but if it is given a little time to rally, this threatened point is hardened, and when stretching is resumed another weak point is developed. Metallic alloys have a mobile structure. Hammering and torsion have a consecutive effect, almost like after-images. Mercury sweats through iron. Copper is welded to tin by pressure. Glass slowly accommodates to torsion.[3] Wax so hard as to be scarcely indented by the thumb nail, placed in a hole above a cork, with pebbles on it, in a few days shows the cork on the top and the pebbles at the bottom, both having passed through the wax as if it were fluid. If a cylinder of lead be placed on a disk of gold and kept in boiling water, which is far below the melting temperature of both these metals, in six weeks shows the gold diffused on the top of the lead cylinder. When annealing breaks down a crystal form the molecular displacement finds a new equilibrium. Bose[4] found that tin and other metallic wire, after the passage of an electric current, required various periods of recovery, and that there were even analogies to tetanus, both complete and incomplete. Some wires show

[1] D. Mendeléeff: The Principles of Chemistry, translated from the Russian, 6th ed., by George Kamensby. Longmans, Green & Co., London, 1897. pp. 26-90-124.

[2] William Thomson, Lord Kelvin: On Boscowich's Theory. Smithsonian Inst., An. Rep., 1889. Washington, 1890. pp. 435-439.

[3] For a collection of similar instances see Albert Dastre: Life of Matter. An. Report of the Smithsonian Institute, Washington, 1902-1903, p. 393.

[4] Jagadis Chunder Bose: The Response of Inorganic Matter to Stimulus. Royal Institution Lecture. W. Clowes & Sons, London, 1901.

fatigue analogous to that of nerves if acted upon for some days. Some chemical substances stimulate and others depress and poison action in both wires and nerves. Bose even constructed an artificial metallic retina, responding to color and with oscillations after the cessation of light, not unlike those shown in the retina. Many other phenomena raise anew the question where to draw the line between physical and physiological processes, as if life activities were foreshadowed in things without life, and above even this great distinction there were a larger unity in and through all. Not only memory but hysteria have been used to designate the behavior of bodies subjected to magnetic and other forces. Again, the Brownian movements, seen in microscopic dust in a liquid which is suspended in water, never cease, for they are found in quartz crystals which at the moment of their formation enclose a cavity of water containing a bubble of gas. Only in 1894 was it more or less explained by Gouy as an oscillation of independent particles, the larger moving slowly and the smaller most active. They are not vital because seen in boiled liquids, and the movement does not depend upon the nature or form of the particles or of the liquid unless it is viscous. They are independent of the tremors of the earth and seem to be molecular movements that invite us to study the far more subtle ones of the kinetic theory.

Crystallization approaches most nearly to life. Crystals grow from the surface by apposition rather than, like germs, from within. They assimilate by a process that mimics nutrition, and may attain a great size. If the mother lye is removed their development is suspended like a seed kept from soil and moisture. Each tends to carry out its own architectural plan and heal wounds, restoring mutilations more rapidly where they occur than it increases at other points. Ismorphism, or their power to replace each other, is comparable to inbreeding or crossing, which is the touchstone of taxonomic relationship. Crystallization is very closely associated with simpler vital organisms in their hard parts, bone and shell. Something like reproduction occurs and crystals are sown like micro-organisms. Liquids in suffusion are especially favorable media for propagating certain kinds of crystals and contact of such a fluid with any crystal germ by an object not sterilized sets up at once the process of crystalline organization which spreads through the mass. In Ostwald's salol the crystals may measure less than one one-hundredth of a millimeter on each side and in hyposulphate of soda they measure a thousandth of a millimeter. Sometimes they are spontaneous generations where the optimum conditions of a solution occur. Often the latter cannot be reproduced and so crystals can be generated only by

infection or filiation. Perhaps the most striking instance of this is the famous glycerine which crystallized spontaneously in 1867 in a tun sent from Vienna to London in the winter. No one saw these crystallize and the conditions under which they occur were entirely unknown until recent years. They have been also accidentally formed in a French factory, and only, so far as known, in these two cases. They appear just as living forms do in a favorable environment and spread only as the Promethean fire did by direct contagion of flame or coal, or as magnets were made only by contact with other magnets before electro-magnetism. The crystals of 1867 have already a very extensive posterity. One factory produces them on a large scale. As they melt at a temperature of 18° C., a single summer might for a time exterminate the whole species.

Most matter is not amorphous but crystalline, and snowflakes, sand, rocks, minerals and most solids in solution tend to take on forms of marvellous intricacy, beauty and mathematical regularity, which are very diverse and of characteristic structure. This used to be explained as a *nisus formativus* of nature. The analogy between the framework of plants (which inclined Sachs[1] to the view that plant protoplasm is at bottom crystalline), as well as the skeletal forms of many lower animal forms and crystals, is very suggestive and has long been provocative of speculation; and now that crystallography is experimental, this morphologic principle seems increasingly life like. The physicist Lehmann[2] has summed up our knowledge of the structure of doubly refracting colloids, many of which strikingly suggest cells, fibres, and other biological patterns, karyokinetic figures, etc. While admitting that protoplasm has a structure that both expresses and directs molecular force, he discredits all strictly vital functions. Schenck[3] supplemented this work from the standpoint of a physical chemist with quantitative measurements of anisotropic substances. These studies show that besides solid crystals there are manifold others of various degrees of plasticity and fluidity in colloids, the consistency of which resembles the softer and most vital parts of living substance. Von Schrön[4] less temperately concludes, from a study

[1] Julius von Sachs: Vorlesungen uber Pflanzen-physiologie. Engelmann, Leipzig, 1887.

[2] Otto Lehmann: Flüssige Kristalle. (With many photographs on 39 quarto pages.) W. Engelmann, Leipzig, 1904. Also his Theorien des Lebens.

[3] Rudolf Schenck: Kristallinische Flüssigkeiten und flüssige Kristalle. W. Englemann, Leipzig, 1908. 1905.

[4] Biologia Minerale. Lettera del Prof. Otto von Schrön al Prof. G. B. Milesi. Estratto dalla "Rivista di Filosofia e scienze affini" Ottobre, 1901. Anno. III, Vol. V. N. 4. Zamorani e Albertazzi, Bologna,

of what he calls the growth, behavior and generation of crystals, that everything in nature either lives or has lived. All young crystals, but not old and fossilized ones, are alive. His greatly magnified photographs show, he thinks, that "petroblasts" or bioblasts pass through certain stages before they are usually called crystals, which latter term designates a degenerate though perdurable stage. Here, too, probably belong Leduc's[1] so-called artificial cells of potassium, ferrocyanide and gelatine, and also Dubois's vacuolids, or, as he now calls them, eobes, produced by barium and manganese salts in sterilized boullion. Burke's[2] now much debated radiobes, so named to chime with microbes, arise when particles of radium are sprinkled on jelly-like decoctions of nutritive substance rendered antiseptic. These structures seem to develop nuclei, to grow by physical metabolism, bifurcate, adjust inner to outer relations, etc. Though aggregates of crystals, they are not, we are told, exactly crystals nor colloids in disguise, but add to this the most primitive elements of vitality. Although "on the bounds between crystalline and organic bodies, they cannot properly be called living, but correspond to some simpler form of life that existed in a distant age."[3]

Not only crystals, but certain foams, resemble cells or tissues. Quincke[4] found in solutions of silicic acid, glue, etc., after evaporation, fibres, fissures, tubes, bubbles and often vacuoles which are either open or closed, join each other or do not, according to the viscosity of the oily liquid. They seem to grow and shrink by diffusion in water. The inclination of their walls, surface-tension and refraction also change with the concentration of the medium. He thought them cellular, yet

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1901. Also Le due Conferenze dimostrative ed una Comunicazione fatte a Napoli al Congresso contra la Tuberculose nel 1900, dal Prof. Otto von Schrön. Estratto dagli Atti del Congresso. R. Pesole, PiazzaB ellini n. 6, Napoli, and Brevi cenni sulla conferenzo dimostrativa su materia e forza (uno dei capitole della vita dei cristalli). C. Sciarrino, Palermo, 1906.

[1] Stephane Leduc: Cytogenise experimentale. Ajaccio, Paris, 1901.

[2] J. Butler Burke: The Origin of Life; Its Physical Basis and Definition. Chapman and Hall, London, 1906.

[3] These studies should tend to rescue from discredit R. Altmann's attempt (Die Elementarorganismen und ihre Beziehungen zu den Zellen, Veit & Co., 1894), to resolve protoplasm into ultimate granules which he called bioplasts and thought to be ultimate vital units essentially crystalloid in nature. These were within the range of the microscope, regularly disposed in viscous intergranular substance, and, though differing in form, were essentially homogeneous. His mistake was in describing as granules various components of the cell known to be both different and secondary.

[4] G. Quincke: Ueber periodische Ausbreitungen Flüssigkeitsoberflächen und dadurch hervorgerufene Bewegungserscheinungen. Annal. der Physik u. Chem., Neue Folge, Bd. 35, No. 12, 1888. p. 580-642.

soluble. Bütschli [1] studied for years emulsions of soluble salts and thinks the structure of photoplasm is like fine soapsuds or beer, crowded and flattened like the bottom of honeycomb cells. Under the microscope these structures show spontaneous flowing movements, explicable by physical principles. Foams have since been much studied as a new avenue of approaching the mysteries of life. By others, such alveolar structures are interpreted not as globules, but as fibrillar, like the threads constituting a sponge. Flemming, especially, thought primitive plasm to be filar and showed that such network structure, the fine threads of which are sometimes isolated and sometimes bundled together, which play an important rôle in cell division and are prominent in large ganglionic cells, is common in cells and can be more or less imitated by coagulations. They are, however, probably a secondary phyletic product. Enzymes and catalysors which set up processes in substances, themselves remaining unchanged, although they shed valuable light upon vital processes, cannot explain the origin of life.

Yet more valuable and stimulating is the recent effort to explain the elementary phenomena of life and its developmental processes by the general principles of physics and chemistry.[2] Capillarity accounts for the sphericity of cells as of dewdrops from diffusion over surfaces. Contact, adhesion, solubility and positive chemotropism are the key to primitive food-taking as absorption is of rudimentary digestion, and excretion of chemical repulsion. The appearance and disappearance of vacuoles are osmoses. The marvellous radilarian framework is due to the mechanism of fluid crystals. Artificial substances perform some, if not most, of the characteristic amœboid movements which are always toward points of least and from those of greatest surface tension which is ever changing under the influence of temperature and many inner and outer influences. Ciliary motion is reduced to metabolic disturbances of myeline threads. Roux's[3] reduction of bifurcation to positive and negative cytotropism, the mechanical imitation of spindles,

[1] J. A. O. Butschli: Untersuchungen über mikroscop. Schäume u. das Protoplasma. W. Engelmann, Leipzig, 1892.

[2] Represented in the Arch. f. Entwickelungs-Mechanik der Organismen, founded in 1889. See in this Archiv. Ludwig Rhumbler: Physikal. Analyse in der Lebens erscheingungen in der Zelle. Oct., 1898, Bd. 7, pp. 103-350, 100 figures. See, too, his Zellen-Mechanik im Zellenleben. J. A. Barth, Leipzig, 1904. Various articles in Ergebnisse der Anatomie und Entwickelungsgeschichte during the last 10 years. Also Dr. Paul Jensen, Untersuchungen über Protoplasmamechanik. Pflüger's Archiv. Nov., 1901, Bd. 87, s. 361-417.

[3] Wilhelm Roux: Der Kampf der Theile im Organismus. W. Englemann, Leipzig, 1881. Ueber die Bedeutung der Kerntheilungsfiguren. W. Engelman, Leipzig, 1883.

rays, cell division, gastrulation and other cytokinetic or embryological processes, Boveri's[1] interpretation of the nucleus as a storehouse of energy and matter, the most-of-all-discussed karyokinetic figures partly reproduced artificially by Bütschli, illustrate this field. The best of this vigorous group of investigators by no means attempt an ultimate explanation of the nature and origins of life, although very outspoken against the neo-vitalists, but they do show that many of its first and simplest manifestations are physical and chemical processes and are best described in the terms of these sciences. Certainly points, currents, gravity, light, heat and all the great cosmic forces to which living forms respond by the many tropisms, tonuses, taxies, kineses, etc., suggest that the rapport between life and its environment, although at first closer than now, is still very intimate.

The above attempts to derive life do not altogether explain the reverse of the universal process of death even in the simplest organisms. Were this done, the origin of life would be resolved into that of matter itself, and the curious question suggested by Roux would arise—into what species, plasm made in the laboratory and without heredity, would evolve, and, we may add, what kind of soul stuff these *eobionta* would have. Celluloid crystals, foams, surface tensions, etc., do suggest that nature may have made countless abortive attempts to produce life, that this was her longest and hardest task, occupying all the vast Archæozoic age, that many methods that we can now partly reproduce were eliminated by selection, and that many more of them culminated in the development of a matrix of physical conditions under which the vital spark was at last struck, and the process of developing plasms may have been going on from the first. Very likely the chasm between all these artifacts and life is so great that all the first and longest geologic age was necessary to bridge it. It is not impossible that at its advent life, instead of being akin to the lowest forms now known, was very different and is now a missing link.

Three other notable theories of the origin of life are the following: In 1865, following a suggestion of Liebig's, Hermann Eberhard Richter, reviving and definitizing old speculations, proposed the theory that germs of lower organisms, detached from rapidly moving celestial bodies, were floating through space, and that life was inseminated on this earth by them. There was thus an interplanetary exchange of germs, and wherever these found a stage of development with warmth, moisture, etc., favorable to life, they adjusted themselves with

[1] Theodor Boveri: Ergebnisse über die Constitution der chromatischen Substanz des Zellkerns. G. Fischer, Jena, 1904.

great plasticity to new environments. Assuming that somewhere in the world, planetary bodies had always existed with life upon them, the latter was assumed to be eternal, and the problem was how these cosmozoa were transported from one world to another. Traces of carbon and petroleum-like substances and, indeed, something akin to humus, are often detected on meteorites. These germs, he assumed, might live a long time in great desiccation and without food, like the spores of micro-organisms in a condition of apparent death. Helmholtz[1] and Sir William Thompson[2] have commented not unfavorably upon this possibility. Not only do meteorites have carbon compounds, but the spectrum of the light emitted from the heads of comets suggests gases containing carbo-hydrates. In passing so rapidly through our atmosphere only the surface of large meteorites is heated. In view of all the failures to demonstrate abiogenesis, Helmholtz thought it a fully justified scientific process to inquire whether life be not thus as old as matter.

Perhaps the boldest theory is that of Preyer[3] (1880) that living substances are primary, and lifeless material is a secondary secretion from it. He assumes that we must emancipate ourselves from the arbitrary and factitious idea that life can exist only on a protoplasmic basis. Primevally the whole substance of this earth was a giant organism of fiery fluid or gaseous matter. The entire movements of and within it were its life. As, however, it cooled, substances like the heavy metals solidified or died and step by step ceased to take part in the life of the whole, and the first dead inorganic masses were formed. As cold progressed and the surface of the earth grew rigid or dead, and the chemical elements were differentiated from what remained, combinations resulting in protoplasm became possible.

Pflüger's startling theory[4] now incorporated into the scheme of Haeckel,[5] assuming that plasma is due to the properties of albumen, first points out the marked difference that while living albumen can decompose itself, dead albumen, as, *e. g.*, in the white of an egg, maintains its integrity for some time.

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[1] H. von Helmholtz: Popular Scientific Lectures, trans. by E. Atkinson. Longmans, Green & Co., New York, 1903. p. 196.

[2] Sir W. Thompson: Report of the British Association for the Advancement of Science, 1871. pp. lxxxv-cv.

[3] W. Preyer: Naturwissenschaftliche Thatsachen und Probleme. Paetel, Berlin, 1880, and Ueber die Erforschung des Lebens, Mauke, Jena, 1873.

[4] E. F. W. Pflüger: Physiologische Verbrennung in Lebendingen Organismen. 1875.

[5] Ernst Haeckel: The Wonders of Life. Harper and Brothers, New York, 1905. p. 345.

This instability of the former is due to the intra-molecular oxygen stored up which dissociates its complex molecules and forms new groups, *e. g.*, water of its hydrogen and carbonic acid of its carbon. In their non-nitrogenous elements the decomposition products of living differ a little from those of dead albumen. But the nitrogenous products of living far exceed and differ radically from those of dead albumen in producing creatin, the nuclein bases, guanine, etc., all of which as a marked characteristic either contain cyanogen (composed of one atom of carbon and one of nitrogen as a radical) or else like uric acid can be made out of its compounds. Hence Pflüger[1] infers that living albumen always contains cyanogen and dead does not. Now living albumen and cyanic acid are both transparent at low temperatures, but set and darken with heat, while with water both break up into water and ammonia and both produce urea, the first organic substance to be artificially composed by Wöhler[2] (1828). Both have great power to incorporate into their molecules other like components and to grow catenally or by chains. Hence Pflüger concludes that cyanogen is a half living molecule and that in it life begins. The first albumen was alive. A constant molecular weight is not necessary for these monstrous molecules, in size like the sun compared to small meteors, and which are incessantly growing and diminishing. Hence the question of the origin of life resolves itself, according to this chemical train of reasoning, into that of the origin of cyanogen. We thus find ourselves confronting the remarkable fact that cyanogen and its compounds can only arise in intense heat, so that they may have originated while the earth was wholly or in part in a fiery condition. Moreover the other essential components of albumen, like the carbo-hydrates and the alcohol radicals, can arise synthetically at high temperatures. Hence life arose from fire, and the long ages during which the earth's surface has been cooling gave plenty of time for the many polymeric formations. The very easy decomposability of compounds into which this root of life enters, and its close relations to carbon compounds were maintained after water arose; and from the chemical relations with its dissolved salts and gases evolved the living albumen, and while they did not produce anything with the morphological value of cells, they enable us to trace the origin of protoplasm. Of course there was a long series of intermediary stages between the most developed Vulcanic pryozoic radical and the simplest living plasm, and Neumeister[3] and

[1] E. F. W. Pflüger: Archiv. für Physiologie, 1875. Bd. 10, S. 251-367.
[2] F. Wöhler: Annalen der Physik und Chemie, 1829. Bd. 15, S. 525.
[3] R. Neumister: Betrachtungen über das Wesen der Lebenserscheinungen. G. Fischer, Jena, 1903.

other vitalists have urged that this chasm is impassable, although living albumen always does contain cyanide or products of its compounds. To the graver objection that such heat compounds would perish when water appeared, it can only be said that during the immense period yet remaining to be bridged after the closest approximation, both chemical conditions and processes which transcend the limits of even that great science, may have prevailed.

As to the size of the smallest bits of matter to which we can attribute life, several writers have made interesting estimates. Errera[1] estimates the limit of smallness of organism based upon a special study of one Micrococcus of the diameter of 0. 1 μ which, he estimates, contains something like 10,000 molecules of albuminoid substance and 3,000 atoms of sulphur. After making several such estimates he concludes that we may say with a degree of probability, which is of the same order as the probability of the molecular theory of matter, that there can exist no organisms which are to ordinary bacteria as these are to higher organisms. Thus there can be no living creatures hundreds of times smaller than those now known, so that the great spectacle of life unfolds within relatively narrow and well determined limits. McKendrick's[2] estimates are yet more interesting and exact. He thinks the smallest particle that can now be seen under the best microscope is about one 20-thousandth of a millimeter in diameter. That certain bacteria are smaller than this is shown by the fact that after porcelain filters strain out all that can be seen, the filtered liquids infect with certain diseases and kill as quickly and surely as do unfiltered cultures, indicating that it is the microbes themselves and not their toxines that are fatal. Weismann assumes the diameter of a molecule to be one 2-millionth of a millimeter, and that a biophore contains some 1,000 molecules. Its diameter would then be one 200-thousandth of a μ, or ten times too small to be seen. Thus a cube, one side of which was one 1-thousandth of a μ would contain 8 million biophores, and a red blood corpuscle between 3 and 4 thousand million of them. The smallest visible particle may contain 1,250 molecules, for there would be 125 in a biophore. The head of a spermatozooid, of which man produces 340,000 million dnring his sexual life, is estimated to contain 25,000 million, and the fecundated ovum 25,000,000 million organic molecules. Even if each molecule contained 10,000 atoms there would be 1,000 million of them. On this

[1] M. L. Errera: Sur la limite de petitesse des organismes. Rev. Scientifique. Feb. 7, 1903. 4e Sèrie, Tome 19. p. 169-172.

[2] John G. McKendrick: Presidential Address. Report of the British Association for the Advancement of Science. Glasgow, 1901. pp. 808-816.

basis each human spermatozoon would contain 250 billion atoms or 250 billion elecluns. This would be only the contribution of the male to his offspring; the far larger ovum would contribute more. Hence, although there are estimated to be 60 trillion cells in the adult human body, there are enough elements in the germ plasm to account for the heredity of all the qualities which connect us with our forbears for countless generations, and to allow each individual to contribute something to all his posterities without drawing upon ulterior atoms or electrons with which life is probably in some unknown way continuous. While, like most biologists, Weismann, *e. g.*, thinks life demands a definite combination of different kinds of molecules and says, "A single molecule cannot live, can neither assimilate nor grow nor reproduce." Haeckel objects, for the plastidule he assumes is a single plasm molecule to which he ascribes not only these powers but memory in Hering's sense. Verworn's[1] biogens, of which plasm is composed, may also be single molecules which may or may not be homogeneous. The plasmogony they effect is not a mixture as Hertwig opines, nor does symbiosis of independent elements explain the nature of the higher units. They are rather like electrons, postulates for economic thinking, and their reality is closely analogous to that of God, freedom and immortality for Kant's practical reason. Although most of them are metamicroscopic, they are not too small to play the marvellously complex rôles assigned them. The secrets of the origin of soul are now more and more clearly seen to be bound up, if not identical, with those of the origin of life, and the beginnings of both stretch back ever farther in time and down the scale of simplicity, so that their primordial germs must be coeval with the dawn of matter and with time itself. Although, as we know them in their present forms, they seem incommensurably different from the life of the physical universe, they are, in fact, products of an evolution that has proceeded by insensible gradations with no rupture of identity.

We next glance at the most characteristic of the more complex vital units, which in modern biology play a part psychologically very akin to that of categories and innate ideas for the philosophers of some generations ago. Nägeli[2] estimates that there are 100 billion of his micellæ in a single moneron of 0.6 m. in diameter. If one of the former has a diameter of 0.0006 m. it would still have millions of ultimate parts, but a single molecule cannot be said to live. The micellæ are not

[1] Max Verworn: Die Biogenhypothese. G. Fischer, Jena, 1903.
[2] Karl Wilhelm von Nägeli: Mechan. physical, Theorie der Abstammungslehre. Oldenburg, München, 1884. Sections 1-5.

themselves living but are so composed as to give rise to life. We can never observe their origin, since their development from an inorganic basis is not an empirical datum, but a result of reasoning from the laws of matter and force. This primitive abiogenesis occurred many times in the past and still occurs, and may occur at any time and place, so that life is polygenetic. In general, the most evolved forms have perhaps the oldest pedigree. Simple forms that have remained at the lower stages of evolution may now be many times reproduced. The micellæ strongly tend to combine into chains and ropes in a crystalloid way, and this arrangement conditions all the later developmental differences of species in an almost fatalistic predetermining way not consistent with the plasticity demanded by broad selectionists. Variation is thus definitely directed and to a great extent independently of the conditions of the environment. His evolutionism is so extreme that morphology and taxonomy are called phylogenetic sciences, but all goes on from the momentum of an internal principle which he calls isagitation (from ἰσάζω, to make equal). Inherent in nature is an impulse to perfection, and over all his idioplasm is a kind of *nisus formativus*, which plays upon the rows or threads of micellæ like a pianist on keys. His earliest probionta, plassonella or young monera are not structureless organisms without organs, but are nearer to unicellular algæ, and over against the hereditary matter of idioplasm is the trophoplasm, which is the nutritive part of the cell. He thinks, as does Weismann, that life probably arose in a reticulated superficial layer of fine porous clay or sand, where the molecular forces of solids, fluids and gases could best co-operate. Under their influences these biophoridæ acquired the power of assimilation such as plants have, then of multiplication, and finally were able to cross the threshold of microscopic visibility, although, perhaps, after enormous periods of time, for before any advantages of differentiation could occur, biophores must have made stable associations into colonies. Nägeli finally thinks that if even molecules have anything like sensation it must be agreeable to them to follow and painful to depart from their attractions and repulsions. Hence, he assumes a spiritual or psychic bond throughout all nature, of which the human mind is only the highest development.

Haeckel's[1] plastidules are chemical molecules which can be

[1]Ernst Hackel: Natürliche Schöpfungsgeschichte. 1st ed., G. Reiner, Berlin, 1868. Systematische Phylogenie, G. Reiner, Berlin, 1894-06 3 v. See also The Last Link, tr. by Hans Gadow, 2nd ed., A. and C. Black, London, 1899. The Riddle of the Universe at the Close of the Nineteenth Century: tr. by J. McCabe, Harper and Brothers, 1901. The Wonders of Life: tr. by J. McCabe, Harper and Brothers, New York, 1905.

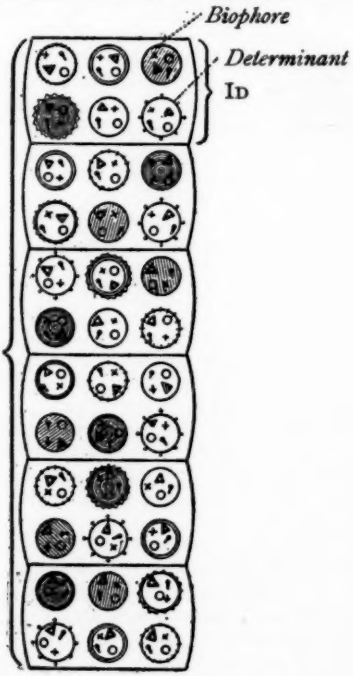
decomposed only into atoms. Hence they cannot divide but they can cause the production of new ones from a nutritive fluid. In a broad sense everything lives, even atoms, for their attractions and repulsions suggest pleasure and pain, but their will and sensations are invariable. In a stricter sense, life is reproduction and that is essentially memory, and this plastidules have, but lifeless things lack. Primordial memory is a mechanical result of the mode of movement of the elements of the blastidules. Their first organisms are monads or now chromacea which grow, as it were, by precipitation of new plastidules and then reproduce by division. At first, they are homogeneous and alike, but the environment adds new inner movements to those pre-existing and these adaptations are transmitted. This differentiation is perigenesis. Each new individual passes rapidly through the stages of its stirp, guided by the unconscious memory of the plastidule, which in higher organisms have both learned and forgotten much, but in lower ones have learned little and forgotten nothing. All the ontogenetic processes of one generation from egg to egg are comparable to a wave with smaller waves representing the successive cell divisions that form and develop the organs during growth, while the history of a species is a larger wave: but since environment changes, the crests and hollows of even these waves are not a straight line, but themselves make a larger wave curve representing the entire history of life. Perigenesis is the efficient cause of this complex and ramified undulatory reproduction of the plastidules. Life has one origin and Haeckel boldly constructs many elaborate genealogical trees for various phyletic groups of animals and plants, Man is given a very elaborate pedigree from the plastidule up. Acquired adaptations are inherited in a Lamarckian sense. He abhors teleology, has been himself a great ferment, stimulated many pupils, and has in recent years popularized his ideas in many papers and several books.

Weismann,[1] who, next to Darwin, is probably the ablest of biological thinkers, has since 1875, wrought out a theory of life that fits and unifies a vast body of facts, and in his last volumes gives a final formulations of most of his views. Life arose by chemical spontaneity long before the first fossils. The primitive *biophoridæ* were produced after countless failures and

[1]August Weismann: Essays upon Heredity and Kindred Biological Problems. Authorized trans. 2nd ed., Clarendon Press, Oxford. 2 v. 1891-92. Studies in the Theory of Descent, translated and edited by Raphael Meldola, S. Low, Marston, Searle and Rivington. 2 v. London, 1882. The Germ-Plasm, tr. by W. Newton Parker and Harriet Rönnfeldt. C. Scribner's Sons, New York, 1893. The Evolution Theory, 2 v., tr. with the author's co-operation by J. A. and M. K. Thomson, E. Arnold, London, 1904.

extinctions, but eventually with a wealth so inexhaustible that vastly more species than ever did evolve might have done so from them. This process, perhaps, occupied more time than all that has since elapsed. These biophores are the smallest units that can assimilate and reproduce, but they are extremely diverse. At first they aggregated, then organized in innumerable ways and relatively few of these products survived and only the fittest of them slowly advanced towards microscopic size. Even if we could compose the conditions for spontaneous generation, we should probably never know that it had occurred, so minute would be its first products. Everything that lives grows and divides so that there was no death at first because there is nothing like a corpse to be sloughed off. Hence, barring accident, the lower forms of life when once started were potentially immortal and from these most ancient beginnings all living forms are developed by a direct continuity of descent. Plasm is like a fluid poured over nature, preserving its every feature, so that their vital structure, large and small, has a definite cause in the environment, to trace which historically for every cell, organ, species and corm is our goal. No one has given such extension to the principle of selection which is germinal, histonal and personal. Each biophore, tissue and individual struggles to survive and in so doing competes for nutriment and space with every other in each individual body. There is ultimately no predetermination and every species is like a traveller and may depart indefiniteiy from its origin and wander about as the environment favors or opposes. When the cell arises the chromosomes contain both cytoplasm, which presides over ontogenic growth and nutrition, and also idioplasm or ancestral plasm, devoted to reproduction. In the former, cell division is differential and produces parts ever less general and more special. Germ plasm, however, divides identically. Instead of disintegrating to form a soma which dies, it is perpetuated indefinitely through successive generations now in the highest as it was originally in the lowest organisms. There may be at a certain critical stage a struggle between the two, and the ancestral elements may overcome and expel the histogenic plasm which makes the body and thus constitute a reproductive instead of a somatic cell. Biophores may be massed into determinants and one, at least, of these presides over every part of the body that can vary independently of other parts. Ids are groups of determinants which comprise all of the ancestral plasm necessary to build up an individual. Very early in the embryo the two kinds of plasm are separated, that for reproduction being set apart as latent for subsequent generations, ready to develop when their time comes. So isolated and protected is it that all the events in the life of the individual

barely affect it and hence acquired qualities are not inherited. To the vindication of this extreme position a wealth of concrete discussion is devoted. Higher yet are the idants which may contain a hundred different ancestral plasms and which is used to explain atavism. Though all these processes cannot be traced in detail, they, in fact, pass over definite tracts and through distinct stages. Even the parts and organs produced by the first divisions in ontogenesis, he seeks to trace as the cells slowly specialize and lose the reproductive power originally inherent in all. In a sense, development into classes, orders, families, genera, species and individuals is thus the disintegration of germ plasm as its progressively specific qualities come



This diagram (for Lotsy's Deszendenztheorien. Fischer, Jena, 1906) illustrates how, although the chromosomes divide equivalently, this does not involve equivalent diversion of the ids. Hence certain groups of determinants may be lacking in some cells, which would therefore have only a part of the hereditary qualities and so could no longer reproduce a new individual.

out. When maturity is attained each single cell has its directing biophore. Each vital element is intrinsically different and is not made so by its position or environment, as Hertwig's epigenesis holds. Germ plasm acquires more and more potentialities up the ascending stages of life, so that although it was at first very simple, it is now for the higher types extremely complex. Plain as this abstract of his theory seems, it becomes indefinitely complicated and requires various ancillary assumptions when he seeks to explain by it, as he does in great detail, the various functions of heredity, variation, regeneration, hybridism, alternation of generations, amphimixis, atavism, parthenogenesis, infection, and most of the other great problems of plant and animal life.[1]

De Vries[2] thinks that variations as now tabulated in curves, showing their range in the same species, are too small to produce the latter by gradual departure from the parent form. He also holds that crossing cannot produce permanent qualities that are also really new, but that, after breeding true for a series of generations, there comes a period of saltatory variation or mutation, and that this is the chief agent in producing new forms. Selection, thus, has a limited range and can only

[1] Mention should perhaps here be made in passing of what is in some respect the counterpart of Weismanism, recently developed by a few pathologists, Cohnheim, Jensen, and Beard which is rudely as follows. Alternation of generations means that at intervals an individual is produced which does not develop but stops at some lower ancestral stage, the next generation reverting to the full normal of the species. This is usually thought to occur only in very low forms but it is now believed that it holds in a changed way in metazoa and even man, both of which have larval structures which degenerate. The embryo proper develops on the larval bases which do not thus constitute new organisms but are the foundations on which development begins *de novo*. These transitory structures or embryonic residua constitute the trophoblast and at a critical period when the pancreas develops trypsin, they are digested as its alkaloids supplying the formic acid intra cellular digestion. This responsible issue has the same continuity as germ plasm, only it is as the cells, and these aberrant germ cells are found in all parts of the body of the young, arising outside of it and migrating into it. They wander anywhere along different paths, but some never reach their goal in the sex organs, and are misplaced but do not degenerate. The embryo is a product of one of the primary germ cells, while the rest are its twin brothers. Instead of producing trophoblastic tissue they may degenerate and sink to a low plane of rapid multiplication and lose the power of building tissue. Although these perverted germ cells tend to produce new individuals they are able only to produce larval, sexual trophoblastic tissues and these may produce a ferment called malignin which destroys the health cells of their host. This is cancer, which causes about one death out of forty.

[2] Hugo de Vries: Species and Varieties, their Origin by Mutation. The Open Court Pub. Co., Chicago, 1905. Intracellulare Pangenesis. Fischer, Jena, 1889.

explain the survival but not the arrival of the fittest. This view is favored by the gaps in the palæontological record. To the illustration of this thesis and its defense against his many critics, he has massed a vast area of facts from a wide biological field. His pangenes are the smallest chemical substances that can assimilate food, grow and divide, and although vast in numbers they are of limited kinds, so that just as the letters of the alphabet compose all words, they can make all living forms. In the simplest creatures all the pangenes are few and act concurrently, but in the higher forms of life they are more numerous and of more kinds. They may long rest quiescent and then mass themselves and surmate their activities in the molecular plasm. Here they multiply and each nucleus stores up all the pangenes of an individual, becoming thus the organ of heredity. From here they migrate at intervals and form new individuals. At first every cell can reproduce itself from the pangenes resulting from the first divisions which are alike. Soon for some this generative power lapses into that of growth only because the cells that compose the body do not receive a complete set of pangenes, for it would be useless to burden them with those for which they have no use. Before long, however, the somatic development becomes unique and apart. Pangenes are distributed not like Darwin's, by permeating all tissues, but always at the moment of division, so that their movements are always confined within the limits of the cell. They have their phylogeny like species.

J. Reinke[1] represents a totally different point of view. Like Lotze, he lays great stress upon the difference between mechanism and teleology, is a dualist and a theist. After pushing physical and chemical explanations to their uttermost, as he always tried to do, and insisting that every form of life is a chemical factory and pervaded by systems of force from the sun, which all structure is to conduct, he finds reproduction, nutrition and sensation to be inexplicable because they have no analogies in nature. Hence he is led to postulate teleological forces not unlike the entelechies of Driesch.[2] These he calls dominants or higher energies. They are not subject to the laws of matter, are metaphysical, unconscious, yet psychic. Each smallest vital part has its dominants and they give all regularity and are revealed to us by the changes they cause in structures. The latter they may find ready-made by earlier dominants. They are also higher dominants of species, and

[1] Johannes Reinke: Die Welt als That. 4te Aufl. Gebr. Paetel, Berlin, 1905. Einleitung in die theoretische Biologie. Gebr. Paetel, Berlin, 1901, Philosophie der Botanik. Barth, Leipzig, 1905.

[2] Hans Driesch: Der Vitalismus als Geschichte und als Lehre. Barth, Leipzig, 1905.

soul is their sum in the individual. God did not create one primitive cell only as Wiegand thought, nor one for each stem, but they are all from, and closely related to, pervading cosmic intelligence. Weismann's germinal selection he calls the Indian summer of Darwinism, whose winter is at hand. As opposed to evolution, he thinks bacteria may be regressive forms, apes, degenerate men and apogamy may arise from sex. His view is in sympathetic rapport with the conscious teleology of August Pauley[1] and with the action according to a purpose without consciousness of a purpose which Hartman[2] pleads for in this field.

Cope[3] calls the organizing force which makes life out of dead matter bathmism and the first unit it produces a plastidule. Anagenesis is the way up and kinetogenesis is the development of organs by movements and tendencies to move. He holds, as does Orr, that habitual acts have a morphogenic function. Katagenesis is retrograde development. Some plants are degenerate protozoons. The first most elementary phenomenon of life is rudimentary consciousness which has attended, if it did not direct, every step, *e. g.*, the development of the heart and intestines and their movements. But every function strongly tends to lapse to automatism and mechanism which is more simple and stable. Thus unconscious memory is basal and ontogeny or diplogenesis is motivated by this fallen but potent memory of the stages of the development of the race. Life is thus energy directed by sensibility or by mechanism that it originated. The beginning was energy becoming conscious, and consciousness having performed its part lapses into habit, function and structure.

Zehnder,[4] starting from purely physical and chemical principles, thinks that the lowest and first life unities are molecules, arranged in tubes or fistellæ, from rings, of which there are millions in the plasm of every cell and which are specialized so that some effect endosmosis, some contraction, others conduction, etc. Each tends to produce another like it and so they double rapidly. They are of different sizes and complexities, Their vortical shape make them permeable for atoms and even molecules which pass through their centre, and this accounts for absorption, swelling and growth. They expand and con-

[1] August Pauley: Darwinismus und Lamarckismus. Reinhardt, München, 1905. Especially Chaps. XI and XII.

[2] Eduard Hartmann: Das Problem des Lebens. Haacke, Bad Sachsa, 1906.

[3] E. D. Cope: The Primary Factors of Organic Evolution. The Open Court Pub. Co., Chicago, 1896.

[4] Ludwig Zehnder: Die Entstehung des Lebens. J. C. B. Mohr, Tübingen, 1899; and Das Leben im Weltall. J. C. B. Mohr, Tübingen, 1904.

tract, but this oscillation is about the constant size and this is the *Anlage* of muscularity. They are, nevertheless, essentially crystalline. Arranged in rows, often with conical ends, they constitute cylinders, contain fluid, and form these simplest tissues, in a square millimeter of which there are about 1,000 milliard fistellæ. No other structure can give such stability. Conductivity once established, psychic life begins, the early evolution of which he traces in some detail. The stellar universe is a larger and analogous vital organism.

Hatschek[1] finds two elementary processes of life, both due to rhythmic or phasic constitutional changes of biomolecules. One is generative and causes increase by division and rejuvenation, and the molecules that regulate these processes are termed generatules. The other is nutritive, regulated by ergatules which are working molecules. The former may change into various kinds of the latter, and, as they contain chemical radicals for all ergatules, they determine their nature, and hence, indirectly, all the properties of the body. The generatules are far more alike, but may change, especially where they are most numerous in the nucleus. The ergatules are very diverse and abound in the body of the cell. Their different kinds are distributed by division to the cells of different tissues according to the functions of the latter. They are derived from primary ergatules which are less differentiated. Outer influence can act on the generative substance in the chromosomes, not directly but only through the ergatules, which are nearest the germ plasm, and receive and transmit the net resultant of them chemically to the germ. This influence of the environment is effected by splitting off still smaller molecules called ergatines (after the analogy of antitoxines) and these directly effect changes in the composition and architecture of the generatules, which cause variation. Primordial vital substance had only generatules and, hence, could only multiply without many phasic processes of growth, and its biomolecules were quite likely far smaller and simpler than those of higher forms of life. As the body develops from one cell, so generatules and later ergatules are always evolving and organizing themselves into cells.

Semon[2] develops in a very able book a psychic primordium. If a stimulus, when it has ceased to work, leaves an after effect upon an organism that persists, this change is called an engramm, and the sum of all inherited and acquired effects in a special line is called a mneme. The simplest bit of living mat-

[1] Berthold Hatschek: Hypothese der Organischen Vererbung. Engelmann, Leipzig, 1905.

[2] Richard W. Semon: Die Mneme als erhaltendes Princip im Wechsel des organishen Geschehens. Engelmann, Leipzig, 1904.

ter, and also all tissues are receptive, but the nervous system is specialized for the engraphy of mnemes. These processes, like many others, are best studied where the division of labor among cells is most developed, because here functions are simpler and clearer than in rudimentary forms of life. Thus the higher is the key to the lower. When two sequent stimuli are often repeated the first may come to produce the effects of both in the organism, and this is eckphoria, which later and introspectively we call association. Both engraphic and eckphoric effects may be caused by fainter and fainter stimuli and then some may act automatically as habituation in response develops. There are also latent effects observable only after the summation of many stimuli. Chronogenic eckphoria underlies and explains seasonal changes in plants and animals, such as ovulation, migration, etc,, while phasogenic eckphoria is the influence of a certain stage of development, like, for instance, puberty upon other changes set up by it, each stage of growth, *e. g.*, stimulating the next by means of the engramms of the race or species in each individual. Thus engramms persist through generations which are phasic repetitions of them and their combinations. The instinctive but adapted actions of young and lower animals are due to masses of inherited engramms. Weismann[1] criticises this theory, which he terms "brilliant and *geistreich*," because, unlike his determinants, engramms do not originate in the germ plasm only but in the soma as well. The engramms of the germ plasm are toned down images of the experiences of the rest of the body, transmitted to it from its various parts, and which become effective at each stage. Engramms are ever pressing germward from every organ. Semon does not know how, but collects many facts which he thinks show that they do so, such as the persistence of a daily rhythm in plants developed from the seed in constant darkness, or in plants transferred from north to south, or *vice versa*. Thus Semon's view is almost the polar opposite of Weismann, since, in fact, everything for the former is the result of the acquired experience of the individual or the race registered upon germ plasm. Upon this view memory is made the key to heredity and also to the states and processes of the "upper consciousness," which must also be explained, although in doing so we must sedulously avoid all terms of introspective origin.

While the above are the more important theories of their type, it may be interesting to résumé from my notes a few similar hypotheses which are either older or less elaborate.

[1] A. Weisman: Richards Semons Mneme und die Vererbung erworbene Eigenschaften. Archiv für Rassen und Gesellschafts-Biologie. Jan. and Feb., 1906. 3 Jahrgung S. 1-27.

Among these we must place Bechamp's[1] ingenious microzymas which are of very different sizes, normally spherical, although they may temporarily take on different forms when closely apposed to each other. Their chemical composition is different and they may undergo specific changes in new conditions. They only really live, and death is the disaggregation of their temporary associations. Yet they cannot die but live on ready for new combinations, and in this form they pervade all earth and sea. God created them. Their chief power is to secrete soluble ferments. This action is essentially dissolutive and they evolve products of decomposition. They strongly tend to associate into organisms of ever higher order. Their lowest amorphous aggregation is glaivine in mother of vinegar, wine ferments, and next higher, in bacteria where they fuse into colonies of chaplet and other form, and third they make cells. Darwin's gemmules move about and penetrate all parts of the body until they reach just the right cells. Each represents the cell in which it arose and they give to the cells they inhabit the power to reproduce themselves. There is an incessant fecundation of cells by gemmules, but only germ cells receive gemmules of all the cells (pangenesis). Outer impressions tend thus to be reproduced in the sex cells, so that these change with the conditions of life. As growth progresses each new cell at birth receives more of the gemmules destined for it. It is, however, proven that gemmules are not transported in the nerves or in the blood, so that the weak point of this theory is how they so freely permeate the body. Hertwig's[2] idioblasts are bits of nuclear hereditary substance that grow and multiply primarily without otherwise changing. They represent all the elementary properties of the cell, each receiving not only just what it needs individually, but, as it were, sparks of all sorts of other ideoblasts that are characteristic of the individual. Some are active in some cells and some in others, according to the environment. In reproduction they fuse and do not juxtapose so that offspring are intermediate between the parents. In each there are dormant all the traits of the race, any of which another environment might have developed. Thus evolution is epigenesis or due to impressions made by different experiences upon originally identical material. Hence his view is opposed to that of preformationists like Weismann. Wies-

[1] A. J. A. Bechamp: Les Microzymas dans leurs rapports avec l'heterogenie, l'histogenie, la physiologie et la pathologie. Lille, Paris, 1883.

[2] Wilhelm August Oskar Hertwig: The Biological Problem of To-Day: Preformation or Epigenesis? translated by P. C. Mitchell. W. Heinemann's Scientific Handbooks, London, 1896.

ner's[1] plasomes are also the smallest vital particles that can reproduce themselves, for that is the cardinal biological function, although they must also assimilate and grow. We cannot tell whether they are eternal or spontaneously generated or whether each has a psychic element. Constituting everything that is alive, they differ immensely from all that is not so. They tend to mass and thus increase in size by intussusception. Most die, but not the gemmiplasm which persists and is little influenced by the environment. This is chiefly a growth theory and little more than that. Haacke[2] thinks that under polar forces living matter tends to crystallize into gemma and these plasm crystals into gemmairs. He gives geometric cuts of groupings, and between these forms and those shown in the cell during its development traces resemblances. The arborizations and other forms these elements take are explicable by the law of equilibrium which is to them self-preservation. Although there is an impulse toward perfection, biology is hardly yet an independent science. Verworn's[3] biogens are living molecules formed, after the analogy of chemical compounds, from lifeless matter. They are permanent, although their composition is ever changing, and are thus comparable with the flame of a candle. They have great power to leaven all that they reach with life by catalysis. These enzymes, as with Ostwald, control digestion, reproduction, and are a kind of energids that accelerate oxidization, Many of them are coordinated and highly specialized in each cell. Maggi[4] starts with amorphous glia which corresponds with Haeckel's unindividualized autoplasm. It is made out of organic matter and from it are first differentiated plastids which are free like bacteria, but which later became associated in monera and yet later combine into vital granules. E. Giglio-Tos's bionomes[5] are vital units which combine into biomads and then into cells. Jäger long ago thought that all dermal and glandular emanations either were, or were very closely connected, with ultimate germinal particles, and spent great ingenuity through two large volumes in working out the relations between sex and smell.

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[1] Julius Wiesner: Die Elementarstructur und das Wachsthum der lebenden Substanz. A. Hölder, Wien, 1891.

[2] Wilhelm Haacke: Gestaltung und Vererbung. Chr. Herms, Leipzig, 1893. See Die Träger der Vererbung. Biol. Centralbl. Juli, 1893. Bd. 13, pp. 525-542.

[3] Max Verworn: Die Bewegung der lebendigen Substanz. G. Fischer, Jena, 1892.

[4] Leopold Maggi: Protistologia, No. xxxiv of the Manuali Hoepli-Serie scientifica, Milano, 1882.

[5] Ermanno Giglio-Tos: Les problemes de la vie. Cagliari, chez l'auteur, 1900-1905.

From Plato's *nous* to von Helmont's *archæus*, animistic theories ruled all attempts to explain life, and later the great school of Montpellier gave wide currency and momentum to theories of vital force. The spermatists and ovists then long divided the allegiance of thinkers. After the microscope opened a new world and chemistry had proven the existence of bodies far beyond its ken, the scientific imagination took flight in micromeristic constructions, some of which, as we have seen, have been brilliant and stimulating in the highest degree. These invisible wonder-workers, if they exist, are the artists of life, older than all fauna or flora, and their remoteness in time is hardly less impressive than their special minuteness. Whether they are mind stuff or real things, they show that man's psychic powers can vie with nature herself in producing marvellously intricate structures, and they make a certain æsthetic as well as logical appeal to the mind. Some of them are wrought out with amazing cleverness and with immense labor and have great explanatory value, while others are cheaper products, but all shed new light upon the categorizing instinct of the human reason, and contribute something to realize the richness, worth and immemorial antiquity of life and of the soul, henceforth one with and inseparable from it.

All the above views transport the most basal and interesting problems of both life and mind to the inconceivably remote in time, small in size and to matter, whether conceived materially or dynamically, till they seem tantalizingly transcendent and the field of ordinary experience appears cheap and rude, a kind of reliquary of nature where and when she was in her creative prime. What used to be called brute matter, for which thinkers have been almost misophobiac, now seems nearer the great first cause, full of far more possibilities and potencies than have been realized, and so much above and so far more complex than mind that science cannot even understand it. Perhaps now, with the marvellous new views of the ultimate constitution of matter, we exalt rather than degrade the soul and life just in proportion as we explain them by physical and chemical forces. Reason is not adequate to grasp these, and our cleverest thought and imagination only formulates our ignorance and is less, not more, than fact. Matter seems more than life, life more than mind, and germ plasm far beyond the power of the brain or soul to comprehend it. Mechanism is most and life the least knowable.[1] We cannot know self in any fundamental sense till we know protoplasm or the amœba, and evolution is only the best case of devolution. In this new orientation and trans-

[1] Konrad Guenther: Darwinism and the Problems of Life, tr. by J. McCabe. Owen, London, 1906.

valuation, it is the undevout materialist and germ-plasmist who is mad, and even dissolution and death lose some terror and acquire some charm, for we are in the end at least resolved soul and body into some diffusive powers, which are the "mothers of life." Which way really lies up and down, progress and retrogression in the vast continuum we call the universe, but which may have no boundaries or breaks in either time or space? Again, the inveterate fallacy of students of the soul, with the exception of a few bolder spirits mentioned above to explain everything by the nearest cause, is in striking contrast with the tendency of biologists to utilize the new horizons of distance and size, although, save the few who accept Weismann's[1] biophores and determinants, almost none of these have followers. As we know it chiefly in cells, protoplasm is no longer primal, homogeneous or structureless, but is pervaded, if not constituted, by a slowly accumulated mass of heredity, with thousands of latent traits, for to live is to habituate. Their momentum still dominates and all that has followed since is relatively easy and brief. Every bit of protoplasm has a long history, or is, in fact, an historic structure, and trophic and reproductive primordia still impel to variations that are independent of present utilities or of recent environment. From these phyletic structures assimilation and dissimilation, growth and reproduction, the most fundamental traits of life, the bases of hunger and love, arose before the oldest fossils, so that their pedigree is lost.

Geike[2] puts the formation of the solid crust of the earth at little less than 100 million years, shortly before the seas were developed and the plankton on its surface, where Brooks[3] thinks life evolved, was formed. Joly[4] thought 55 million and Dubois 36 million years the probable time since river beds began, and Lord Kelvin,[5] in 1862, estimated from the rate at which the earth's crust cooled that nearer 20 than 40 million years must have elapsed, and many estimates of increasing temperature downward must have approximated this calculation. George Darwin[6] concludes that the moon broke away from the earth some 56 million years ago. How can we reconcile the fact that the first life was doubtless aquatic with the chiefly igneous nature of the oldest rocks. I can only suggest that perhaps the convulsions caused by the breaking away of

[1] August Weismann: Essays upon Heredity. Clarendon Press, Oxford, 1891-92.
[2] *Opus cit.*, p. 153.
[3] William Keith Brooks: The Foundations of Zoölogy. Macmillan, New York, 1899.
[4] *Opus cit.*, p. 153.
[5] *Opus cit.*, p. 153.
[6] *Opus cit.*, p. 153.

the moon from the volcano-girt Pacific, which Pickering thinks occasioned the Americas to split from Europe and Asia, the general contours of which are so conformable, made the oldest rocks so metamorphic that in the heat and the mixture of their semi-moulten magna all the earliest records were obliterated. This would explain the fact that, when the crust petrified and the earlier clear palæontological traces were laid down, we have so early so nearly all of the great branches of the animal kingdom, although the highest are represented only by their lowest and most generalized forms, especially in the case of vertebrates. Despite this cataclysm, some of nearly all the then existing species must have survived in some locality as in a veritable Noah's ark. If, as de Vries[1] thinks, species arose by mutations, and these in early times were greater, in more directions and with shorter intervals between their periods, the geologic time available might more easily suffice, while a longer period would be required if variations were very gradual.

It is a common view that the lowest organisms are most persistent and least variable and that many of them have not changed since the first appearance of life, but have continued to breed true to their primitive type. Weismann, Poulton and Darwin held this view. The latter was "sorely troubled" at Lord Kelvin's limitation of geologic time and would have preferred Fry's estimate[2] of 2,700 million years since life began, the assumption being that evolution started very slowly and was accelerated as it advanced to higher types. But, instead of being most rigid, should we not rather regard these earlier forms, when heredity was, as it were, young and had not acquired its momentum, as most plastic and least stable, as more are now coming to think. This view Bastian[3] has lately wrought out with great boldness and ingenuity. The apparent persistence of simplest forms he thinks due to incessant *de novo* production from non-living matter, just as crystals arise wherever conditions are fulfilled. Instead of being Silurian, countless ephemeromorphs are always arising, a peculiarity of their molecules being to take on life forms. These are ever arising in great profusion by archibiosis. The lower of them are heterogenic and pass into each other by transformation where *per saltum* variation may even cause a rotifer's egg to develop into a ciliated infusoria. To this class of cases much of Bastian's book is devoted. When we conceive an atom as the core of a

[1] Hugo de Vries: Die Mutationstheorie Veit. Leipzig, 1901.

[2] Sir Edward Fry: The Age of the Inhabited World and the Pace of Organic Change. Monthly Review. December, 1902, Vol. IX, pp. 42-53, and January, 1903, Vol. X, pp. 68-83.

[3] H. C. Bastian: The Nature and Origin of Living Matter. T. F. Unwin, London, 1905.

group of positive electrons, like a sun, around which negative particles revolve in orbits like our planets, and an atom of hydrogen as different from one of iron, *e. g.*, only in having more planets or different orbits, so that new elements like thorium, uranium and perhaps helium are undergoing spontaneous generation, why, asked Bastian, should we deny mutability, plasticity and spontaneity to the vastly more complex foramenifera? Rapid and immediate response to changed environment, with the influence of the past less and that of the present greater, causes in low forms of life alterations that seem fitful and lawless, but these preform the discontinuity of variation and the mutation which Bateson and de Vries find in higher forms. Both are leaps across perhaps not yet well settled taxonomic demarcations. This, too, would account for the universal distribution of simple forms. The similarity of old and new types is due to like conditions. Bacteria may occasionally arise spontaneously, so that not every germ disease is due to contagion, and so may some torulæ and molds. Links of relationship that unite organisms are therefore not all hereditary, but are partly due to uniformity of laws acting under uniform conditions, or to constant matrices which are ever fertile. Of these ever upsurging new forms the highest animals arose from oldest, man with his brain and reason being very likely as aberrant and transitory as the monstrous reptiles of the Trias and Jura, the beginnings of the far higher forms that will supersede him being perhaps in the act of arising from matter to-day. Finally, Bastian agrees with Newcomb that among all the countless stars there must be "thousands and perhaps millions" on which the conditions are so like those on the earth that life surely exists, though doubtless different, in some worlds higher, in others lower, than here, but in all different.

If the way up to life, being once found, is still kept open and is still traversed as much and even as slowly as at first, this, of course, does not affect the view that its original construction was long and hard. There may be many ways and those now used may short-circuit the old ones, or the best may be selected and all the old ones discarded. New plasm may be formed by rapid recapitulation of the mode of origin of the first. Protoplasm must be of innumerable kinds and compositions and the new, although undistinguishable from the old, may be essentially different and without all its promise and potency. The first plasm may have exhausted itself in giving birth to the higher species, and the persistence of low ones may be due to progressive incapacity of nature to equal her first effort, so that when the higher forms have vanished only attenuated, abortive and ever simpler ones will be left, life as a whole dying from the top downward, as old men produce ever less effective sperm.

The power to breed true may decay and only late and novel forms may transmute, indeterminate heterogenesis marking decay at the root; or, conversely, life in the far future may be more vital and both the plasm and species of to-day be the products of nature's prentice hand, so that the phylogeny of the future will recapitulate that of the past with a much increased rapidity and economy as the individual recapitulates the history of the race, perhaps even higher species transmuting into others. Dreameries like these do not begin to exhaust the speculative possibilities in the field where so little is known, so much is possible and the hunger for new light is so great. More seriously we may ask how, if life is ever arising anew, we can explain the law of both palæobotany and palæozoology that if a species dies out it never reappears in a later geologic age; also the fact of life-zones and of the disparity between homotaxy and contemporiety, now well accounted for, would be harder to explain[1] than if all existing protoplasm is derived from previous protoplasm and is now so complex that its present form must be the result of a very long period of development since it first became protoplasm.[2]

Plants, says Fechner,[3] might well ask whether restless human bipeds were of any use in the world save to prepare carbonic acid for their leaves and when they die to furnish with their rotting bodies nitrogen for their roots. Plants eat, spread and fertilize their seeds, and insects are only love messengers to bring pollen to the female blossom. The plants could exterminate the humans by sending forth a bacterial army. Fechner was led to postulate souls in plants as one result of his conviction that the psychic elements of individual life could be preserved after death in a high unity. Indeed, under all physical processes he assumed a psychic rudiment which must cross more than one threshold to become conscious, so that there must be a psychic corresponding to the physical continuity. Fischer[4] thought the word "*eidos*," idea, meaning form, suggested that there is something psychic in every organization of a type or species which is comparable to a school of art or philosophy. Motion had no beginning and is the life of the world, and rocks and earth are a cadaveric rigidity after the secretion of which protoplasm is left over. Life is persistent, not gener-

[1] H. Nichelson and R. Leydekker: Manual of Palæontology. 3rd ed. Blackwood, Edinburgh, 1899.
[2] O. Hertwig: The Cell. Tr. by M. Campbell. Macmillan Co., New York, 1895.
[3] G. T. Fechner: Nana oder über das Seelelenben der Pflanzen., 2 te Aufl. Mit eine Einleitung von Lasswitz. L. Voss, Hamburg, 1899.
[4] Fischer: Ueber das Princip der Organization in der Pflanzenseele, 1893.

ated, but sprang from the absolute basis of all being where it existed in potentia so that there never was a time when all the world was dead, and plant souls are the summation of molecular souls. Némec[1] thought he had demonstrated structures and functions in plants not unlike those which Apathy found in the higher metazoa. He concludes that many vascular plants possess special structures for conducting stimuli in the cytoplasm of their cells, so that the similarity to like processes in animals is far closer than had hitherto been supposed. After demonstrating structures that seemed homodynamic, his conclusions were confirmed by studying experimentally the propagation of stimulus, and this indicated fibres set apart for this purpose, for their bundles could be followed directly to the seat of the bending movements, and both fibres and the function of quickly responding thus vanished again. He finds just under the dermal surface of the root cells sensitive to geotropism, and these cells are characterized by the presence of grains of starch which serve to orient the root to gravity. Their specific weight is greater than that of the protoplasm of the cell, so that they press against different parts of the surface in different positions of the root. The stimuli is transmitted with undiminished intensity, and in some plants these movable starch grains are developed to a special organ comparable with the static organs, which in metazoa are provided with statoliths. This author agrees with Czapek that there is no difference in principle between many reflexes of plants and those of animals, and that not all movements of plants can be regarded as antetypes of metazoan reflexes.

Before and especially since Darwin showed the adaptive movements of plants, their many modified forms of circumnutation in epinasty, hyponasty, nictetropism and sleep, their sensitive responses to light, heat, gravity, moisture, contact, etc., compared their movements to those of animals, the tip of branch and root to a brain, studied their cunning devices for catching and digesting insects, their reactions to their visits in cross-fertilization, and their plasticity under domestication, botanists have applied many experimental methods and measurements which show that if plants do not have a soul, we need only to magnify their movements in space and condense or accelerate them in time to see that their motor reactions give them an exquisite rapport with their environment, which is as good as, if not better than, psychic. The brilliant and epoch-making experiment of Bose[2] goes much further and

[1] Dr. B. Némec: Die reizleitenden Strukturen bei den Pflanzen. Biol. Centralblatt, June 1, 1900. Bd. 20, pp. 369-373.

[2] Jagadis Chunder Bose: Plant Response as a Means of Physiological Investigation. Longmans, Green & Co., London, 1906.

shows that there is no important reaction of the most highly organized animal tissue that is not also found in plants. Their motility under electrical and other stimuli is not confined to young plants, buds or leaves, but they are very sensitive to fatigue, which has its curve of excess and recovery. Every stimulus has its latent period, its threshold, its optimum conditions, and may be summated into actual tetanus. Plants are sensitive to many drugs. Alcohol exalts or depresses their functions as it does those of higher animals. Some have sense organs that can be located. Many of them pulsate with waves of turgidity and with regular, though usually rather slow, systole and diastole and thus they circulate sap. Plants may be killed, although not without a marked preliminary death spasm with subsequent *rigor mortis* followed by relaxation. They die more easily if fatigued. The rate of transmission of a wave of stimulus is measured. Sap rises from the root to the highest tree top not chiefly by capillarity, but by active suction, also measurable by special apparatus. Growth is rhythmical, consisting of a wave up and another back, the real growth being the excess of the first over the last. Plants can be habituated after a refractory period. Their sleep is caused not by darkness, but by real exhaustion. Their tropisms to sun, earth, currents, their power to twist and twine is affected by age, previous activity and many other circumstances. Excitation is transmitted from one part of the plant to another by lines of protoplasmic reaction, along which the stronger the stimulus the greater the velocity. In both plants and animals the anode blocks transmission and most motile response is all or none, as with the animal heart, while acids and alkalies have an action quite akin to that of the heart. In all these reactions there are characteristic differences between species, old and young plants, and sometimes between individuals of the same kind and age. Even the author's experiments with such common plants as celery and lettuce show a behavior in them that can hardly be entirely excluded from psychology. Thus the unity between plants and animals is fundamental and detailed. Everything in the latter is at least begun in the former so that experimental psychology must henceforth have a botanical section. All is vital and yet all becomes mechanical in proportion as it is known. The general order of phyletic development in the plants was first algæ or perhaps fucoids, then acrogens, conifers, cycads, palms, with phænogams and their fertilizing insects late, and it would be an interesting next step to know how the physiology of early and late plants compares. It is only because our studies of the mind have been so chiefly human, adult and analytic of the consciousness of the present moment that they are too provincial to see the ocean of soul of

which our mind, which we think is so supreme, is but one outcrop, or that we find it so hard to realize that upon any large and sound definition of soul life, more of it existed and perished before man appeared than all that has arisen since. Wherever there is vitality there is *psyche*, and science not only shows nothing to contradict this deep instinctive belief that crops out in animism in all primitive religions, in poets, ancient philosophers, is imbedded in the structure of language, myth and popular opinion, but plants show not only what Aristotle called the nutritive and reproductive soul, but add to these subtle responses to all the influences of their *milieu*. The psychic life they show is the oldest and most dominant part of the soul in our narrower sense of that term and here, therefore, we must find the apperception organs for all the rest of our knowledge of the latter. Man's secondary consciousness is only one of the countless allotropic forms of soul, although even it may by an act of faith be postulated as but one of the many forms of energy sometime to be explained under the law of cause, and all perhaps quantitatively. Just so far as psychology becomes a natural genetic science it will trace all higher powers back to those we have in common with plants and the simplest animal forms, and *vice versa*, derive all the former from the latter.

The earliest plant life was very abundant, but of few kinds, and those so perishable that palæontological traces are rare. Indeed, vegetation has been chiefly terrestrial and its marine forms low in type. The simplest of these are very plastic and can subsist in water, hot or cold, saturated with salt, lime, sulphur, silica, and about everything soluble. Some can endure freezing and great desiccation. Bacteria, though derived and not original forms, must have existed to account for decomposition. The peat mosses and then the ferns and equisetæ, lycopods of the coal age, and later yet the seed plants or spermatophytes on which animal life is most dependent for food, was the order. As opposed to the common view, some now hold that life originated on land and in fresh waters and migrated to the sea. Despite his control in agriculture, plants have done a vastly greater geologic work than man and are far more plastic to diverse conditions than are animals. The latter is doubtless especially true of the first forms of which so little is known. While it is unsafe to infer from the responses of the very high and sensitive plants of tropical India, with which Bose found his most striking results, to primitive plants, the botanical realm probably shows no exception to the general rule, true also for zoölogy, that the responses of lower forms of life are relatively more in structure and those of higher forms in function.

Every detail in both the life and form of every plant is due to stimuli from its morphological environment. Heredity is the innateness in the individual that was acquired by the species. Probably all these structural and functional adjustments to conditions were originally compulsory. Inflorescence, *e.g.*, is the condensed result of a slow modification of leaves into petals, each stage of which had some external cause. Reproduction and all its intricate stages, types and attendant phenomena was impressed item by item upon substance endowed with two traits alike marvellous, viz., plasticity to receive and persistency to retain. Growth, size, shape, texture, position of leaves and buds, color and every other item which distinguishes one species from another, are one and all the accumulation of what were primarily individual reactions to light, temperature, moisture, chemicals in air and soil, contact, gravity, etc. All differences in plant structure are massed effects or records which science must read of the way and degree these forces have acted upon them or their ancestral forms; hence, to know plants completely is to know their history. In other planets where these incident forces were differently composed or proportioned, plant nature would be changed exactly as much but no more than they. Moreover, an individual life is not the unity it seems, but an aggregate of units, or, as Bateson[1] calls them, allelomorphs, which are often of very diverse origin, independent one of the other, but which in reproduction may be combined in every possible way. While in old established forms acquired qualities modify heredity only very slowly, so that Weismann is essentially right that the net results of individual life upon germ plasm are minimal or naught, the past determining everything, only Lamarckianism in its most extreme form can explain the evolution of races, species and their every diversity, great and small. Hence, preformation theories lack chronological perspective in the same way, though in less degree, than does creationism itself. If every change from fertilization to maturity is dependent upon a series of stimuli, instead of being spontaneous as extreme experimental embryologists think, then all the

[1] "Each such character, which is capable of being dissociated from or replaced by its contrary, must henceforth be conceived of as a distinct *unit-character*, and as we know that the several unit-characters are of such a nature that any one of them is capable of independently displacing or being displaced by one or more alternative characters taken singly. We may recognize this fact by naming such unit characters allelomorphs. So far we know very little of any allelomorphs existing otherwise than as *pairs* of contraries, but this probably merely due to experimental limitations and the rudimentary state of our knowledge." W. Bateson: Mendel's Principles of Heredity. University Press, Cambridge, 1902. p. 27.

more must this have been true of the development of species for which stimuli must have been relatively more and response slower and more uncertain. From this new view point psychology must henceforth study all structural and functional adjustments as the key to all perspective and reflective adaptations. The moving equilibrium that pervades animate nature differs from human intelligence in nothing fundamental save that in the former new adjustments to new influences in the environment are slower in time. What we call consciousness is derivable from the suddenness or the biometamorphosis with which new balances are attempted and attained and to the more complex and manifold changes that this involves in higher organisms which are susceptible to shock in a different way. Thus the genetic psychologist may regard man, as von Baer has suggested, as at bottom a vegetative being (most of his organs concerned with metabolism, circulation and reproduction arising from the entoderm on which is superposed an animal or psychomotor being, the senses and brain and, to at least some extent, the muscles, arising from the entoderm).[1] In some sense we may speak of latent mind in vegetation or of life as nascent mind and mind as patent life and in so doing lay a new fillet of wool on the creations of Schelling, Fechner and even Bruno. and admit that speculative sagacity and even oriental pantheism, like that which animates Bose, are not to be regarded as *a priori* anti-scientific.

Of the early pre-Silurian animal ancestors of man from unicellular protists up to the oldest skulless, jawless, limbless monorhine vertebrates, Haeckel makes fifteen progonotaxic stages, of all of which palæontology shows no trace, although each has living relatives. He admits that other pedigrees might be made, although for some he expects further knowledge to verify his hypothetical forms. In the oldest Archæan age, of which, if we accept the planetesimal theory, there can be no assignable lower limit, although there are no fossils, there is evidence that life was abundant, while little is known of its character and it is separated from the next age by a great unconformity, as is the next or proterozoic age from the palæzoic, where abundant fossils are first found. It is believed that the earliest were algæ, rhizopods, infusoria, plastoid, with multicellular hollow vesicles. Later came gastrula forms with two germ layers; then primitive worms of an ascending order, ending with those that showed anticipations of a notchord, and then the low skulless vertebrate. During this period the intestinal cavity, a respiratory tract, which was first in the gut

[1] Ernst Haeckel: Evolution of Man. 5th edition trans. by J. McCabe. Putnam, N. York, 1905. 2 vols.

itself, renal functions and the flexible axis between the intestine and a ganglionic chain which was the *Anlage* of the spinal chord, were developed. Of course Haeckel abhors the inverted evolution of Dohrn,[1] who has himself since repudiated it, that the amphioxus, thought to be the parent of all vertebrates, was a degenerate cyclostome, that even ascidians and tunicates are decadent fishes and that all animals are the progressively fallen offspring of man who was at first sole and supreme. He thinks the tunicates, although degenerate, are the nearest blood relatives of the vertebrates, although only from a common root and not in their line of descent. There is no doubt that touch, smell, complex movements, rudimentary vision and taste were developed in the primordial sea before the age of the oldest fossils. Life histories, habits, reproduction, recapitulation by the individual of the traits of its race were established in a fundamental though very simple way, and movements that were adapted to needs and adjusted to stimuli were developed and concatenated.

It is even harder and more conjectural to select from the psychoses of living lower forms those traits that were near the beginning of the line of descent of man's mind than it is to trace this stage of the pedigree of his body. Probably the food quest is the first field of development of an individual *psyche* and this is often quite intricate in the protozoa. An amœba can squeeze an acineta to obtain the young from the ovarian aperture, which it seizes as soon as it emerges and ultimately digests. Paramecia gather about a bit of bacterial zoöglœa, show antipathy to alkali, troop about a drop of dilute acid like a crowd about a popular orator, maintaining an optimum distance where the intensity suits them, although they often seem to mistake bits of filter paper for food. Actinophrys watches for the spore cells of pythium as the ciliated monadic germs emerge, captures and devours them all. Actinaria wave their tenticles inward in the presence of soluble food so that Jordan[2] thinks they taste, Romanes[3] that they smell, Nägeli[4] that they are only stimulated muscular action, Loeb[5] that the ciliary surfaces are also, if not chiefly involved. Parker[6] shows that

[1] Anton Dohrn: Das allgemeinste Gesetz der Natur in alles Entwicklung, 1864.

[2] David S. Jordan and Vernon L. Kellogg: Animal Life. D. Appleton & Co., New York, 1900.

[3] George J. Romanes: Jelly-fish, Star-fish and Sea-urchins (International Science Series). D. Appleton & Co., New York, 1885.

[4] Carl von Nägeli: Mechanisch-physiologische Theorie der Abstammungslehre. R. Oldenburg, München and Leipzig, 1884.

[5] Jaques Loeb: Vorlesungen über die Dynamik der Lebenserscheinungen. J. A. Barth, Leipzig, 1906.

[6] T. Jeffrey Parker: Lessons in Elementary Biology. Macmillan, London, 1901.

in some kindred forms the waving of the lip-cilia caused peristaltic gullet contractions of the sphincters of the oral disk. Hodge[1] thought that vorticellæ, after filling up with yeast torulæ and violently disgorging them when found unfit, learned to avoid them. Some phenomena ascribable to thigmo- and chemo-tropism and even to ions are really due to the food instinct. This primitive hunger cannot, yet, at least, be explained as endosmosis or as chemical affinity between the animal body and its food as Dantec suggests. If the psychologist can say of any element of the soul that it was first, it is something which has developed, through we know not how many stages from some such germs as the above illustrate, into appetite, and this has ever since been one of the most potent springs of mind. It is perhaps not only the oldest but the strongest of all ontologic impulsions and involves some discrimination of touch-taste or of smell or both, as well as some differentiation between the euphoric state of satiety and the painful one of incipient starvation. The mode of getting food first differentiates animal life as mobile from plant life as sessile, so that here the genetic psychology of the individual takes its rise. It is at first about the only content of the infant soul and gives shape to nearly all forms of animal life in the struggle for survival. The first formula of will in the zoölogical world is, "I would assimilate and raise this or that to the plane of my somatic life and so grow." Perhaps when we know why one thought or feeling is preferable to another it may sometime be clear that it is at bottom because it favors cerebral or general nutrition. An animal is a creature that seeks its food by active movements of the whole or a part of its body and it is at home wherever it finds it.[2]

Another primitive motor orientation was probably caused by light. This, of course, began long before any rudimentary eye and is seen even in bodies that appear to us transparent. As early as 1878 Strassburger[3] showed that certain plant spores moved toward light at a rate determined by its intensity. Some twelve years later similar tests began to be made on lower animal forms and of such studies there is now a copious literature. Loeb[4] found that rudimentary organisms either gathered in light of a preferred intensity or parallelled the axis of their bodies to

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[1] C. F. Hodge and H. A. Aikins: The Daily Life of a Protozoan. *American Journal of Psychology*, Jan., 1895, Vol. 6, pp. 524-533.

[2] For its paidological outcrop see Sanford Bell: An Introductory Study of the Psychology of Foods. *Ped. Sem.*, Mar., 1904, Vol. 11, p. 51-90.

[3] Eduard Strassburger and others: A Text-Book of Botany. Trans. by H. C. Porter. Macmillan, 1903.

[4] Jaques Loeb: Die Orientirung der Tiere gegen Licht: Sitzungs ber. d. phys. Ges. Wurzburg, 1888. S. 1.

the incoming ray, or both. In a box, one end of which is near a window and the other darkened, some forms gathered at the light end, some at the dark and some at intermediate points, as they are positively or negatively heliotropic. Verworn[1] and Altmann found an orientation to a certain intensity of light which they thought to be more or less psychic. Miss Towle[2] studied cypridopsa in a case covered with a glass prism filled with India ink, so that one end was dark and the other light, as Yerkes[3] did entomostraca, daphnia and other crustaceans, and all were found distinctly phototactic. Such creatures tend to move to and fro and settle in the light intensity to which they are attuned or accustomed. Some of them change from positive to negative response and they alternate between the two. Choice is often affected, as is the retina, by the degree of light from which the creature has just come. As to color, Burt and Lubbock[2] found daphnia preferred yellow and green, Engelmann[2] that navicula seemed to have preference in the following order: red, yellow, green, blue, violet, although intensity may be a more important factor than chromopathy. For some low orders of life it seems that the limit of susceptibilty at both ends of the spectrum is nearly that of man. Graber[2] found marked response to color in the simplest forms of life. Some of these earlier experiments did not sufficiently eliminate the heat differences of the different spectral colors, nor consider the movements and attitudes of the features to be tested with reference to the direction from which the rays came, nor did they determine the shock causable by sudden changes of light. But it is certain that eyeless, nerveless beings thought to be more or less like the very earliest human ancestors are keenly alive to light in ways not yet explicable photochemically save by theorists, as if some optical function were early diffused throughout the body. Light preferences may have been affected by the sea level to which the creature was accustomed and have been to some extent both cause and effect of its habitat. Perhaps, too, in palæozoic times the atmosphere made the quality of daylight, and possibly even night, very different from what it now is, but, although some amœboid forms of life seem to show little diurnal rhythm, for most grades of existence day augments and darkness depresses activity. It is not known that even this ancient change ever produced true ephemeridæ whose spontaneous life was limited to one day. Thus the chief time markers, day and night, early began to cadence life to their rhythm which has since developed into sleep and waking. Life entirely in the dark is probably derived and not original.

[1] Max Verworn: Psycho-physiologische Protisten-Studien. G. Fischer, Jena, 1889.

[2] For complete reference see p. 212.

Hence a light appetency or hunger arose with optima more or less definite and specialized, and the phototropic eye of the new-born babe, like everything else, has its long ancient phyletic history of which we as yet know so little. Even light was probably at first ancillary to metabolism.[1]

Primitive organisms respond, some of them, very exactly to thermal stimuli, seeking the optimum of temperature most favorable to their life processes. Placed in troughs, one end of which contains ice, with a lamp under the other, they orient and migrate, settling where conditions are best. They can be acclimated in temperatures more or less different from all those to which they are wonted. They have their upper and lower limits above and below which vital processes are suspended. Contrast effects are produced by which those coming from colder environments seek higher and those from warmer seek lower temperatures; also habit effects by which they settle at points in the scale most nearly like those they have just left. Both these have their respective human analogues when men warm themselves after cold and seek coolness after heat and also find difficulties in adjusting to tropical or polar climates. Some are acclimated and others can adjust to far greater thermal extremes than man and some to less. Sympathy began with warm-blooded animals, and to keep their young warm is one of the primordial factors in parental care and love. The social instinct, too, as Sutherland has shown, is partly due to huddling for mutual warmth.[2]

Contact is the only stimulus that may be older than hunger, or the three states of matter, solid, fluid and aerial or gaseous, life doubtless began in the second, and it is conceivable that its haptic experiences may have been often limited to changes of pressure due to diverse rates of movement in water. Where thigmotic and stereotactic impressions occurred, they were with films, surface tensions, food, each other, or with enemies, and only rarely and later with shore, bottom, rocks, etc. The almost sole movement of a primitive group of simple forms, of which the paramecium is a type, is a forward push, then on meeting an obstacle a backward thrust, a turn to right or left at an angle dependent on the stimulus, with slight rotation of the body, and then forward again in a new direction, and the reaction is the same to chemical changes, surface, electric and

[1] For the outcrop of this psychosis in infancy, mythology, etc., see the author's study with Dr. T. L. Smith: Reactions to Light and Darkness. *Am. Jour. of Psy.*, Jan., 1903, Vol. 14, pp. 21-83.

[2] For the recrudescence of this ancient pyrotactism in children and its rôle in human life, see the author's study with C. E. Browne: Children's Ideas of Fire, Heat, Frost, and Cold. *Ped. Sem.*, Mar., 1903, Vol. 10, pp. 27-85.

other currents. For Spencer the primitive experience is a bunt and the first psychic progress consists, perhaps, of an incipient sense of light and dark, or in anticipatory touch, which is the mother of sight and all the other senses. Bottom creepers love crevices and may develop responses to points, curves, compression, changes of permeability, cohesion, thickening, etc. (aero-campo-tropism, taxis, kinesis, or peran-synaph-pachym-osis, etc.). Pressure changes not only in the oral end but in different parts of the body slowly develop reactions of different intensities and kinds as they are favorable or inimical to life in various degrees, and bodies are oriented along branches or edges squeeze into holes and cracks, hug against each other, cling as parasites, habituate themselves to thick or rare fluids, appose their bodies and attach their larvæ to certain forms or textures, distinguish food by its feel, are at home in certain, while oriented toward and perhaps exploring, greater or less densities, seeking or avoiding solids, etc. Such multifarious experiences with hardness are the psychogenetic basis of the very word "objectivity," and tactility is the root of reality. Hence, the epistemology that would subjectivise things into thoughts is only a grimace or affectation because what is fundamentally motivated by, and based upon, such manifold experiences of our eozoic ancestors through ages, compared with which all the time since man appeared is but a moment, cannot be eradicated by the decadent dreameries of speculators isolated from contact with actuality in artificial conditions of life.

Reactions to chemicals must have played an immense rôle when life was young and aquatic. Sedimentary rocks were once in solution, and in volcanic action, heat melted and dissolved them, far higher tides than now eroded them. The ocean may have been much like the Sargasso sea; it may have had salt, lime, silica, chloride of magnesia, potassium, and every mineral of the earth's crust, still found at least in small quantities, dissolved in it with every vegetable and animal substance. There were oozes and muds of diverse consistency on the way to become soils, and all these conditions made the cradle in which life in its infancy was rocked. Experiments with forms of life imprisoned in a drop and under a microscope slide, by Loeb, Hardesty, Garey, Nägeli, Dantec, Schürmeyer, Bokorny[1], showed them to be variously chemo-, tropo-, taxo-, kinetic, to be acutely oriented to oxygen, alkali, carbon, narcotics, and to water (alkalo-, aero-, oxy-, narco-, and hydro-tropic and phobic). Chilomonas enter but cannot get out from a mildly acid drop which acts as a trap, perhaps because the acid reduces their strength and they dispose themselves radially toward the top and respond to the stimulus of its partial desiccation by evaporation and if the acid is strong they may whirl until they

[1] For complete reference see p. 212.

die. Oxytricha swims into a dense solution which kills it. Chemical stimuli usually act on all parts of the body at once but in different degrees in different parts. Around diffusing acid drops, there are two invisible boundaries, an inner and an outer, and crowded within the neutral ring paramecia zigzag. If they are accustomed to an alkaline fluid to which they are negative in the culture jar, and then become attracted to an acid, or else are impelled to it by the neutralization of the alkali. When transferred to still water they are neutral to most chemicals and then resume their old sensitiveness. Massart found that increased measured osmotic pressure caused fluid to pass out of the organism and a decrease into it and that this stimulus caused motion. Carbon dioxide attracts it and yet they need to excrete it. Pfeffer thinks the effects on the outside of their bodies may be beneficial and opposite to the internal effects. In general, chemical influences underly every vital functions and pervade the entire physiology of life. Such phenomena as the above are far below restoration, yet are prelusive of it, are associated with each other and with the food quest and metabolism in ways not yet understood, and suggest some of the reverberations yet persisting in man of ancient pelagic influences[1] and that one day physiology, if not psychology itself, may be expressable in chemical formulæ and show in what close rapport water life originally was with the elements.

Even electrical phenomena now and probably from the first has produced motor and perhaps psychic responses in the lowest forms of life. Verworn,[2] Roux,[3] Wallengren,[4] Kahlenberg,[5] Ludloff, Loeb,[6] Pearl,[7] and Jennings[8] have sought to show various rheo-polo-galvano and electrotonic effects, orientation with the diffusion lines of ions, the reactions generally increasing

[1] Frederick E. Bolton: Hydropsychosis, *Am. Jour. Psych.*, Jan., 1899, Vol. 10, pp. 169-227.

[2] Max Verworn: Untersuchungen über die polare Erregung der lebendigen Substanz durch den konstanten Strom. Pflügers Archiv, 1896. Bd. 62. S. 445-448.

[3] Wilhelm Roux: Ueber die "morphologisschen Polarisation" von Eiern und Embryonen durch den electrischen Strom. Sitz.-Bericht. d. k. Akad. d. Wissenchaft zu Wien. Math. u. Naturw. Classe, Bd. 101, pp. 27-228. (Ges. Abhandlg., Bd. 11, S. 540-765.

[4] Hans Wallengren: Zur Kentniss der Galvanotaxis. Zeitsch. der allgemeine Physiologie, 1903. Bd. 2. S. 341-381, 517-555.

[5] Ludloff: Untersuchungen über den Galvanotropismus. Archiv. f. d. gesamte Physiol., 1895. Bd. 59. S. 525-554.

[6] Jacques Loeb: *Op. cit.*, p. 191.

[7] Raymond Pearl: Studies on Electrotaxis. Am. Jour. Physiology, July, 1900, Vol. 4, pp. 96-121. Some Aspects of Electrotactic Reaction of Lower Organisms. Report of the Mich. Acad. of Science, 1901.

[8] Herbert S. Jennings: Contributions to the Behavior of the Lower Organisms. Columbia University Press, 1906. Macmillan Co., agents.

with their atomic weights of velocity. Some think these effects due to anions, and that they resemble those of acids, while others hold that the heavy metallic kations were prepotent. Some think the reactions of infusoria to electricity are different from those to other stimuli. Most hold this action to be cataphoric, causing the body to swell on the cathode side to which the fluids in the body are drawn. This is true of dead but perhaps in less degree of living animalcules. Paramecia are drawn backward toward the anode by a strong current while trying to swim in the opposite direction. There is a peculiar struggle between a contact stimulus and a constant electric current, the characteristic arrangement of the cilia in thigmotaxis being overcome for an instant then resuming its sway, then the electric condition dominating again. This orientation continues and the two stimuli do not give a resultant action, the cathode usually being more attracted than the anode.

Again mention should be made of geotropism and of changing specific gravity according to needs and at different stages of growth, and the depth at which the creature lives as Pratt, Davenport and Williams have shown.[1] The heavier the animal the greater the effort in swimming. It is hard for a mosquito larva to reach the surface, cypridopsis must move fast or sink, cyclops goes by jerks, sinking between each, and other forms hold themselves up by clinging with their antenæ to the surface film or to a solid object. Others regulate their gravity by imbibing or expelling water through lymph spaces or vacuolated cell regions. Thus correlation is made with density, which is associated with food habits, although a movement up and down does mean to pelagic forms what they do to land animals who live on the bottom of their sea of air, yet they are sometimes exquisitely oriented, although with no height or depth phobias like those common in man.[2]

Of course existing protozoans probably do not exactly represent the first forms of life either psychically or otherwise. They may not be proto-organisms in the sense of representing the original forms of life. Those studied above may have departed far from their starting point under altered conditions. Such reactions as are outlined in the last few paragraphs but samples the field in which all the data obtainable must be derived from which to infer primordial responses through the ages mainly before those represented by the oldest fossils. But it must have been somewhat thus that they reacted to the influences about them and to remoter teluric and cosmic forces. The rapports were so long, close and manifold, the plasticity was so great,

[1] For complete reference see p. 212.

[2] See the author's Fears. *Am. Jour. Psychol.*, Jan., 1897, Vol. 8, pp. 147-249. Falling, p. 154.

and the retention of effects so persistent that we must seek the broad basis of the pyramid of which man is the apex here. Our minds as well as our psychological processes are derivative of these unconscious antecedents. The kinds of motor response may show great unity of formulæ and be conditioned by the shape of the body, but they are not those of a machine determined entirely by different tensions on different sides. Immediately after death the effects are different. Nor do these minute creatures react like small masses of protoplasmic substance, as Dantec thinks, but as individuals. Some respond very like muscles exercised from higher organisms, others move about as if in quest of definite objects like the white corpuscles in our blood, or like various digestive cells, and there are in vertebrates close analogues to ciliary movements. Cope,[1] strange to say, says that "The conscious cell is the primitive cell, and the unconscious cell is the independent or specialized cell," and adds, "Brain cells are the least modified of all those that constitute the soma of the metazoa, and thus they resemble most nearly the simple beings which constitute the lowest forms of the protozoa," and more lately amœboid movement, causing make and break of lines of conductivity, has been suggested between the processes of the cerebral neurons to explain associations and disassociations respectively. Watkins[2] even infers that evolution may be regarded as a compounding of minds and that man is a psychological as well as a biological colony, so that what we call psychic unity is not that of a simple thing but of a system. Verworn[3] thinks every cell, whether free and independent or aggregated in man, has something akin to mentality, so that mind is not superadded. Many hold that the physiological is a degenerate form of the mental. It is certain that the highest creatures are built up out of functions and structures of the most primitive kind and that rudiments and reverberations of the earliest forms of life are cardinal to our own, so that their study is the beginning of anthropology.

The world riddle of the lower limit of mind is far older than Des Cartes, who made the summary *coup* of declaring all animals to be automatic machines. Evolution, however, tends to trace mind further and further toward the origin of the universe and to assume continuity from the first, as it must do to work smoothly. The present recrudescence of Cartesianism had an able and representative expression in the attempt of Beer,

[1] Cope, E. D.: The Evolution of Mind. Am. Naturalist, Oct. and Nov., 1890, Vol. 24, pp. 899-911 and 1100-1016.

[2] Watkins, G. P.: Psychical Life in Protozoa. *Am. Jour. of Psy.*, Jan., 1890, Vol. II, pp. 166-180.

[3] Verworn, Max: Modern Physiology. Monist, Apr., 1894, Vol. 4, pp. 355-384.

Bethe and Uexküll, who proposed to objectify nomenclature.[1] For all reactions of unicelular animals and for plants they proposed the term antitypia, and for those of higher forms the term antikinesis or back movement. Receptive organs are called anelective if their states can be changed by stimuli of different quality, and elective if only a special kind of stimuli operates. Their terminology is both ingenious and elaborate. Psychology must be expressed in physiological terms. We cannot imagine what the ants feel or sense. Ziegler[2] would banish every philosophical term and rejects the idea of consciousness as "utterly worthless." Verworn in his protista studies uses the term stimulus movements (Reizbewegungen) as common to lower animals and plants, but adds to this spontaneous movements. The term *kleronomia* has been suggested for all inherited qualities which would include reflexes and most instincts as opposed to *enviontic* designating individuals acquisitions even the term psycic is called a vulgar designation for higher nervous functions. Massart[3] has given yet more detail objective nomenclature for plant and lower animal life, including the kinds of stimuli and reaction, strength, direction, intensity and results of each.

The criteria proposed for determining the lowest limit of mentality are many and diverse, and are perhaps about the best tests and keys to the philosophy of an observer. Of these, the power to choose or select one of two or more responses pleases those who emphasize free will, but is hard to apply for even inanimate objects between two opposite forces may differ in their response because of undetected and uncontrolled differences within or without, so that their action is not exactly predictable. If, and when all is known, man himself may be found to be only a complicated machine while the simplest thing that lives seems at times to show traces of freedom, and Metschinkoff thinks phagocites choose dead rather than living cells and tissues, and Wundt that they have some selective power with regard to their foods, qualities of light, etc. Those who hold vital adjustments to be mechanical may just as logically be told to draft their machine as may those who think a

[1] Th. Beer, A. Bethe and J. von Uexküll: Vorschlage zu einer objectivireden Nomenclatur in der Physiologie des Nervensystems. Centralblatt f. Physiologie, June 10, 1899, S. Bd. 13, 137-141. Biol. Centralblatt, Aug. 1, 1899. Bd. 19, pp. 517-521.

[2] Heinrich Ernst Ziegler: Theoretisches zur Tierpsychologie und vergleichenden Neurophysiologie. Biol. Centralblatt, Jan. 1, 1900. Bd. 20, pp. 1-16.

[3] Jean Massart: Versuch einer Einteilung der nicht-nervösen Reflexe. Biologisches Centralbl., Jan. and Feb., 1902. Bd. 22, pp. 41-51 and pp. 65-75.

form of life is higher chemistry be told to synthetize it in the laboratory. The power to learn or profit by experience is another current criterion of mind, and closely connected with this are its definitions, as memory or associative memory and, with ability to rectify errors this concept usually draws the line between psychic and non-psychic far lower down even to the dawn of life for an essential trait of protoplasm is its educability by its environment. Semon's[1] mneme includes every effect of a stimulus that persists after it is removed and assumes that plasma is water to receive and steel to retain. Radical as it is, this conception is better, but highly speculative and lends itself to the very abandon of mystic dreamery, yet the scientific imagination has perhaps never found a field for such wholesome and stimulating suggestion as in the modern plasma cult, fulfilling here the highest function of theory. On the whole, it is also the most objective of tests for psychic rudiments and experimentation, and permits less ambiguity in interpreting results. As progressively exact adaptation, life itself is at least quasi-psychic, developing as if informed by an intelligence far superior to man's, with more wisdom implicit in an amœba (to know which completely would be to know all) than in the most comprehensive cosmic philosophy. A third group of tests is affectability, feeling-tone, elementary pleasure and pain. An animalcule that has attained food, its thermal and luminous optimum, and rests, must be assumed to have attained a modicum of satisfaction. But here interpretations differ widely. Is it due to the selection of a future end and of the means thereto, or is it tropism? When Norman's[2] earth worm was cut in two in the middle the anterior part crawled on with little disturbance, while the posterior half writhed as if in agony, and the same result was seen if the front half was bisected again. When the ant and even Bethe's[3] bee was severed at the abdomen, the front end where the cephalic ganglia were situated, kept on sucking honey which flowed out at the middle. It is hazardous to infer sensation from movement, and yet these are our only bases of inference and the motive of selection and the struggle for existence is assumed to be the

[1] Richard Semon: Die Mneme als erhaltendes Prinzip im Wechsel des organischen Geschehens. Engelmann, Leipzig, 1904.

[2] Norman W. W.: Dürfen wir aus den Reactionen niederer Thiere aus den Vorhandensein von Schmerzemfindungen schliessen. Archiv für die gesammte Physiologie, Apr., 1897. Bd. 67, S. 137-140.

Also, Do the Reactions of the Lower Animals against Injury Indicate Pain Sensations? Am. Jour. of Physiol., Jan., 1900, Vol. 3, pp. 271-284.

[3] Albrecht Bethe: Vergleichende Untersuchungen über die Functinen der Arthropoden. Pflüger's Archiv für Physiologie, Oct., 1897. Bd. 78, S. 509-545.

attainment of agreeable and the escape from disagreeable states. Hence with this genus of tests we can do little or nothing. To all this Wasman[1] vigorously suggests that instinct cannot be resolved into botanical tropisms. Moths often fly at right angles to the flame instead of being drawn into it as by a magnet. Caterpillars creep up twigs to their tips as if positively heliotropic, when they are hungry, but lose this power when they are sated. How, he asks, could they turn about when they have eaten the twig clean and so not die of starvation? The truth seems to him to lie somewhere between a segmental and a centrally located seat of instinct and he deems the array of objectivizing terms useless pedantries, and defends the use of analogies, with human experiences. Consciousness proper he would limit to the last stages of evolution and probably to man, and he thinks evidences of it diminish just in proportion as we recede downward from minds like our own. We must not becloud the theory of reflex action. Yerkes goes so far as to suggest that the ant with its exquisite senses, docility and social life "possesses a form of consciousness which is comparable in complexity of aspect with the human." The sanest conclusion perhaps, is that "the theory of tropism does not go far in helping us to understand the behavior of lower organisms; on the contrary, their reactions when accurately studied are, as a rule, inconsistent with its assumptions." Jennings[2] thinks that the method of trial and error is the most essential feature in their conduct. Tropism is "a fixed way of action pressed upon the organism by the direct action of external agents," each class of them having its corresponding tropisms. Stereotyped reactions do occur, but there must be some way of distinguishing error from success, for after several trials error tends to be avoided. He holds that these reactions are of a much more flexible and less machine-like character than the theory admits. The trial and error scheme "leads upward, offering at every point opportunity for development and showing even in the unicellular organisms, what must be considered the beginnings of intelligence and of many other qualities found in higher animals."

For one, I prefer to defy the current horror of anthropomorphism and to show a decent respect to continuity. Wherever the term consciousness is introduced there is confusion and no one ever yet accepted another's definition of this pro-

[1] E. Wasman: Einige Bermerkungen zur vergleichenden Psychologie und Sinnesphysiologie. Biol. Centralblatt, Mar. 15, 1900. Bd. 20, S. 342-350.

[2] Herbert S. Jennings: Contributions to the Study of the Behavior of Lower Organisms. Carnegie Institution of Washington, Washington, 1904.

tean term. Only to speculative and monodeistic minds can the question between some psychic rudiment and tropism be so put that we must cleave to the one and despise the other answer, for both are at the same time true, and both are involved in the same reactions. Each sheds light on, and perhaps is necessary to, the other as are mechanism and life, and only dogmatism, unscientific partisanship, a passion for premature conclusions and hazy faith in what some far future will show, can take sides or strive to precipitate an answer to this unusual and inscrutable cosmic riddle. To say that a miser is chrematropic; a religionist, theotropic; one who loves home, œchotropic; a sailor, pelagotropic; a drunkard, methutropic; that when we are hungry, we are sitatropic, that boys who love girls are parthenotropic-, taxic-, tonic-, kinetic-, phobic, positively, negatively, etc., would be true, but not the whole truth. Some supernal being from a distant planet large enough to need a microscope to see man, might describe us in such terms in the early stages of his knowledge of us. What is wanted is not so simple a formula, but details, variations, the origin and history of such appetency; and so summary a terminology is sure to tempt many to rest in a sense of finality, and not to recognize it as merely a set of names for our ignorance and spurs to further investigation.

Finally, sagacious as are all these experiments, and valuable as are the results, we must not forget that they are narrower in scope and less characteristic than are the data that come from patient investigation of life histories in natural habitats from birth to death. While some of the lowest of these creatures tend to respond exactly in the same way during the very act of dividing, and the young act just like the old, the conditions of experimentation are often more or less strange to them, and are often far more specific than anything in their previous experience. Just as no laboratory tests have yet been devised that satisfactorily calibrate the general ability of children and even school work and examinations fail to do so, so these lowly creatures have a free, spontaneous life outside, often with daily, seasonal and age variations. Wherever a larval state can be detected and studied, however brief it may be, its reactions are as different from those of adults as are its forms. Power to adjust suddenly to change is overestimated by the old pregenetic conception of mentality. The naturalist's method seems too simple to the modern experimenter with his new arsenal of apparatus and exact methods. Of course, some of the elementary microscopic forms could not be studied by direct observation in their home conditions and must be domesticated under a cover-glass so that the problem how the creature lives out its fully rounded life in the normal condition to which it is most

addicted is more answerable for the larger and higher forms to which we now turn.

Our next general group must, therefore, comprise roughly, the forms now thought nearest to those represented by the earliest fossils that are at once abundant, fully featured and pre- or sub-vertebrate, and which, like, *e. g.*, the trilobites of the Ordovician age (when they were represented by seventy-seven genera, declining to thirty-one in the Silurian and tapering to —in the Tertiary,—a creature which seems to have both run and swam and had tactile antennæ) are known to have passed through a series of marked developmental stages from the time when the young were old enough to fossilize and maturity. From this we may infer that the species had already undergone long stages of evolution which individual members of it were recapitulatory when they first appeared in the rocks. Psychic development in this age probably "approached somewhat nearly to that now possessed by correspondingly low types." "Higher biological types within the same order have certainly developed since in many cases, and probably higher mental functions, but some of Ordovician forms have suffered biological and probably also mental degeneration."[1]

Of instincts on this higher plane that show distinct genetic features, perhaps no modern forms that have been so well studied are more likely to be typical and suggestive of the cephalopods and gastropods that were typical of early Paleozoic times, than the modern fresh water snail, Physa studied by Dawson and allied forms by Cole (1) and Yung (10), very like the ancient gasteropods observed by Montague, Tait, Tye, Tryon, and Adams. Not only are there great individual differences, but young snails seem less sensitive than older ones, and act somewhat as the older ones do when tame. Those half-grown recover quicker than adults when equally disturbed. Very young snails rarely tap with their syphon when placed in a beaker directly from the pond, as older ones do, and their spontaneous and stimulated movements are simpler. Like all the helix forms of molluscan shells their type of growth suggests evolution and progressively "larger mansions for the soul" and body. Studied first over several hundred acres in Michigan, where they abound, they were found to be minutely adapted to their optimum conditions, having chosen marginal and littoral zones, temperature, shade, sedge, decaying debris, and to have provided for possible desiccation, for Physa does not burrow like bivals, and forms no epiphragm to withstand drought. As it creeps along the bottom it spins a ribbon of slime, and when

[1] T. C. Chamberlain's and R. D. Salisbury: Geology. Vol. II, p. 364. H. Holt and Co., New York, 1905-1906.

it needs to rise this is curled into a tube and anchored so that it can stop anywhere in its upward course. On reaching the surface film it turns its body about and its disk takes in oxygen. Here it feeds, and in going down after attaching to the surface it spins another line, which is at first transparent but which may be used several times even by other snails. Like other pulmonates it can rise or sink according as its lung is full or empty. Carmine grains show that these lines do not stretch, although they may be a foot or two long. . If it turns before reaching the surface it gathers in the line. It rises steadily like a toy balloon till within perhaps a centimeter of the surface and then accelerates, having a strange sense for a surface or for a solid which lies in its course before reaching it. It rarely spins a downward thread if its lung is empty. A hair may be accepted and used for a line of their own make. The tenacity of the mucus and of the spinning of its thread depends upon the intake of food, and it is less strong than the threads of air spinners, like spiders, which must sustain their weight. It seems hard for a well snail not to spin, but they cease to do so during hibernation or during cold or darkness. In flowing water they rarely spin but hug the bottom tighter to avoid being swept away. Fine gravel, stems and a rough but not precipitate bottom, which favors anchorage, increases the tendency to spin. Although they rise chiefly for air they do not always do so at the time of greatest respiratory need so that there are other, perhaps mechanical, impulses to that act. Physa is very sensitive to jars upon the surface even though it may lie some distance below it. This sense causes them to react on a tadpole or beetle that comes near them. When placed in deep water they always turn toward the shore and they rise and descend almost vertically, and seem to detect very slight angular difference from the line of gravity. When moving along the bottom, especially if it is an unaccustomed one, they project their syphons into long tentacles and tap along like a blind man with a cane. Wherever they are they at once seem at home as soon as they touch the surface film. The soil of a certain consistency in contact with the head seems to be stimulus for burrowing. It is important to observe the daily life in a native habitat before transference to aquaria, although snails readily adapt themselves to any conditions and can be tamed, and even accustomed to being handled. Other studies show that snails have considerable sense of direction. Land snails can retrace their course probably by a trail of slime for rods; seem attached to their mates and to localities. Closely allied forms react to odors (Sprengel), heat, light and even sound, taste (Nagel)[1] and others to geotactic stimuli in a way which

[1] Wilibald A. Nagel: Der Lichtsinn augenloser Thiere. G. Fischer, Jena, 1896.

is measurable (Davenport),[1] while intense light provokes, in Physa, great activity, with growing insensitiveness to mechanical influence and subsequent exhaustion (Pearl).[2]

As the snail and bivalve type of life of the Ordovician may be slightly inferred from their highest modern relatives or descendants, so the life of the great crustacea of the mid Silurian age which reached their culmination in the Eurypterus of the Devonian and carboniferous period may be, at least, to some extent approached from the study of modern crabs. The great restriction of shallow sea area in the Silurian era, which shows more species than any other during the tertiary and the adverse conditions attending the closing paleozoic period did not restrict their orthogenic development so that their pauperitic forms are few and this attests the vigor and the value of their structural and ecological paradigm of life. Rock crabs have keen and far sight, are timid and fly to their hole at the slightest alarm. They cannot live long under water and if they are frightened off a beach, dig themselves tight into the sand at the approach of every great wave. Land crabs travel by night in swarms, in May and June, and always in straight lines, even over houses to the shore, where they bathe a few times, lay their eggs in the water, and return to the mountains. One small species of crustacean builds conical nests of sea-weed where they rear their brood. During the moulting season, the common hard-shelled crabs are said to post sentinels to protect their comrades during their unprotected state. The lobster buries the uneaten part of its food in a heap of gravel and mounts guard. Certain crabs open cocoanuts by an ideal, invariable and the only way possible for them. Other aid anemones, which are their commensals, in attaching themselves to their shells. Even the young hermit crab, when he is first given shells or molluscs rushes to them, hesitates, mounts the mouth, and rides about until the tenant is dead, and then it tears it out and takes its place. Their love of change and activity impels them often to accept new and worse shells. In changing, the crab explores, passing from one to the other home, as if comparing by trial and use, and at last darts quickly into the new one. They pass through six metamorphoses before reaching adolescent[3] form, suggesting recapitulation of, so far, unexplored phyletic stages, and their bodies by this time soon become very asymmetrical, perhaps because they strongly prefer dextral shells. Yet young ones can adjust themselves

[1] C. B. Davenport: Experimental Morphology. Vol. I. The Macmillan Co., New York, 1897.

[2] R. Pearl: The Movements and Reactions of Fresh Water Planarians. Quart. Jour. Med. Sci., Vol. 46, pp. 509-714.

[3] See Thompson: Proc. Boston Soc. Nat. Hist., Sept., 1904.

to sinestral shells with less inconvenience than the old ones. Spaulding's[1] experiments (1904) on hermit crabs with the simple maze showed that they could profit by experience in association by vision and taste, and he believed that they could "reproduce, or if one will, vaguely remember." Yerkes[2] (1902) has shown that the crawfish can slowly acquire a simple labyrinth habit, and learn to turn always the right way to food when the chemical senses are excluded, some fifty to one hundred trials having established an almost invariably right choice of one out of two passages. He later showed that the green crab could be taught to go in a nearly straight line to its food instead of following a devious path as on its early trials. Dearborn (1900) found a little less individuality in the crawfish than he expected, but found them very susceptible to horrification and that touch was more important in their lives than sight.[3] Rotation produced no trace of vertigo. He measured their traction power and pinching strength. If they could not, when placed upon their backs turn over within five minutes, they gave it up. Most could be "hypnotized" by holding them still for about a minute when they became rigid, for ten or twenty minutes and aroused themselves suddenly. There was far greater variability in the conduct of each individual at different times than difference between one individual and another. Testing reaction time required painful stimuli, causing great psychic irritation. Inconsistency and absence of correlation between the results of the various tests was one of the last writer's conclusions.

Perhaps the first air-breathers were the upper silurian insects, the cockroaches and scorpions, the fossils of which show true spiracles, but it is certain that insect life had already begun upon land in this primeval age. All the Devonian insects which were rather abundant, as land vegetation was increasing, seemed to belong to the old net-winged order, some of them had chirping organs which of course implies hearing. It is amid the rank herbage of the carboniferous age, however, that insects appeared in great numbers and in many varieties, especially dragon flies, grasshoppers, cockroaches, spiders, scorpions, centipedes, etc., although flies, butterflies, bees, ants and social insects generally were still wanting. Honey-lovers had to wait the appearance of true flowering plants. Some insects of this age are found in vast numbers and among them occurs the largest insect known, the phasma, a foot long and with a 28 inch spread of wings. All the hexapod palæozoic insects are

[1] E. G. Spaulding: Jour. of Comp. Neurol. and Psychol., March, 1904, Vol. 14, p. 49.

[2] Robert Yerkes: Habit Formation in the Green Crab. Carcinus granulatus. Biol. Bulletin, Oct., 1902, Vol. 3, pp. 241-244.

[3] For complete reference see p. 212.

highly generalized, some inclining to each of the three now widely separated orders, neuroptera, orthoptera and hemiptera. When we come to the Jura some 150 species are known in the trias alone, of which three-fourths are beetles; here, too, the higher groups begin. Even miocene vegetation was much more abundant than now, and more tropical, hence insect life was more plentiful and all orders including the highest are found. Some 2,000 fossil specimens having been discovered, some bits of sedimentary rock being black with their remains. In all Europe there are now 50 species of ants, but Heer found more than 100 species in a single miocene bed all winged. From this he inferred that loss of wings and the development of neuters came later in connection with the further evolution of social habits since the early tertiary. The miocene indusial limestone in France is a cement of cast off cases of the larva of the caddis fly. In several tertiary amber beds made of conifer resin over 800 species of insects have been perfectly preserved, and Scudder found 1,000 species including 7 out of the 16 known fossil species of butterfly in the Green River Shales.

Insects are now represented by many hundred thousand species and varieties, the oldest forms of which can be traced to the earliest geological age, and in them the marvels of instinct culminate. Insects live in the earth, air and water, construct intricate homes of many typical and purposeful forms, provide with amazing sagacity for the food and shelter of their young before the eggs are laid, by choosing a place within or upon animal bodies, plants, soil where they are sufficiently or best nourished, lay in the kind and amount of provision needed, devise many ways of preparing, preserving and accumulating food, and guarding it against robbers. They care for their eggs in elaborate ways, domesticating and rearing slaves and pets, seem to plant and harvest and cultivate fungus-gardens, gathering honey and pollen, secrete wax, silk, chitine, cellulose, poisons, develop many kinds of warning color, organize communities so elaborate that they are comparable with human social and political organizations, spin webs with vast mechanical difficulty and make balloons and float off on them, migrate great distances and in the utmost order, organize forays, fight pitched battles, carry on campaigns, have senses and modes of communication we cannot understand, show memory, fear and anger, migrate and hibernate, and seem to be hypnotizable, have intricate modes of reproduction, show memory both active and passive, have definite habits of individual cleanliness and of domestic and public hygiene, construct and set traps for their prey, besides their hard work have play spells, develop funeral habits, have a strange but usually unerring sense of direction, educate their young to pass through

distinct developmental stages after as well as before beginning their active life, construct almost mathematical cells, are masons, tapesters, carders, make diving bells, trap doors, have complicated customs of marriage flight and swarming, and do so much of the cross-fertilization of plants that most of our flowering species could not exist without them. From even such mere chapter heads of entomological psychology (to the detail study of which scores of the ablest minds of the present and recent past have given their lives and developed a vast literature in a field, which for its purely scientific as distinct from its highly economic value, university chairs should be established), the question arises and just in proportion as we read and observe, grows insistent whether if intelligence is adjustment and the accumulation of the results of experience, any other form of life, not excluding man himself, has attained any such perfection. Certainly none of the higher vertebrates can compare with insects in this respect. Their typical and communal activities and their individual ingenuity and inventiveness in meeting unusual emergencies are alike extraordinary, and the naturalist in this field meets with what Huber calls "brilliant flashes of reason." Experimental tests with insects show both surprising limitation to modes of response and also amazing cleverness in the original solutions of the problems presented. How could the ant, *e. g.*, have better met its conditions of life, structural and environmental, if it had from the first been endowed with human reason? Must we not conclude that psychic organization of the insect world is due to the fact of its age, for it is perhaps hundreds of times older than man? Its teeming populousness, too, has all this time made its social stimuli relatively greater than the environmental stimuli as compared with species with less individuals, so that mutual help has thus been more developed.

The above three types, not in man's line of descent, but which are far lower than even his animal pedigree and can be traced with much certainty, show not only great development of digestive, eliminative, and motor apparatus, respiratory, circulatory, reproductive, nervous and sensory mechanism and function, but cumulative and recapitulatory heredity, as well as stages of somatic and psychic evolution. The spiral and enlarging shell begins with the foramenifera, the nautilus, the only surviving representative of the once large and numerous tetrabranchiata, retiring from each chamber as it grows larger, and maintaining connection with all only by its siphuncule. The method of growth of the crustacea is by successive moults and that of insects by metamorphosis, the larvæ of the latter often showing more sagacity than the full imago. These three methods of development are all recapitulatory of the history of

the race, and have long been standing tropes of evolution to higher stages. Another conclusion forced upon us is that every tool, apparatus, muscle, structural part is certain to be utilized to the very uttermost. A carapace is strong and hard just where and to the degree that there is actual strain or attack. A claw or tentacle, eye, limb is used in every possible helpful way, and just as there cannot be any perfect living brain without a mind, and perhaps *vice versa*, so structure and use are one and inseparable. Every curve, hue, contour and size may be a matter of life and death, every mottle in the wing has a sufficient cause and each sportive variation not at once helpful tends to vanish. Prodigal and wasteful as she is of individuals, nature went through long and hard labor to produce types and so is very economical and careful of them. Even earlier forms that have gone the way of the lost cystoids of the Cambrian, the astrocods of the Silurian, and the ammonites and blastoids of the Devonian, and many others that seem to have vanished have, in fact, doubtless persisted in direct continuity in forms that varied beyond our power to trace them during the dark ages of transition, so that instead of dying, between the two successive but unconforming geologic periods, the old forms were transmuted beyond our power to recognize them. Precisely the same is true of other phyla. Many types of soul life have vanished or been transformed. Very likely vertebrate life would have seemed at this early stage aberrant or decadent, for its powers of adaptation to the manifold environments were probably far less than those of insects, which to the philosophical onlooker would have seemed the crown and entelechy of animal existence. A question we cannot answer is whether forms that were long ago more diverse, larger or abundant, also had in their early day a proportionately and higher development of instincts, so that their modern survivors have followed the law of once high and then decadent human stirps in repeating, in a conventional rudimentary way, conduct once far more evolved. This, however, would seem to harmonize with the mechanical nature of many responses, while the power to solve new and individual problems suggests that some instincts may be still in a process of formation. To my mind the most probable statement that can be made is that insects now do much that was learned in the early stages of their phyletic development, so that in observing them we are often face to face with processes far older than man or the present geological configuration of the globe. It is this momentum that makes animal instinct generally, and especially in its lower forms, so automatic. It need never have been discursive, but it is now chiefly innate, and in it is the condensed and impacted experience accumulated from an almost infinite number of generations,

the momentum of which impels nearly all the activity of these lives. It is thus impossible to account for them if the condensed results of experience are not, at least in some degree, inherited. Again, most insects with higher instincts are social, and a few now solitary were once so. A community is an instrument by which the aggregate develops the ability to profit by the smallest groups or even individuals within it. Not only division of labor, but the fact that each cell as it were of the body politic moves about, all of them combined over a wide area encountering divers chances, and then when they come together have some power of imparting and following their experiences, makes for manifold orientation or plasticity in the state. Higher animals are intelligent and domesticable, somewhat in proportion to their gregariousness in feral states, and ants and bees and other insects huddle and mutually impart their psychic states by contact as if they were parts of one body so intimate is their intercourse, yet each goes out by itself and accumulates impressions as it does food and honey for the common good. Thus they are "separate as fingers, but one as the hand." Observation and experiments show great difference among individuals and there are geniuses and fools in every large colony and swarm. Yet in the insect city the individual is more subordinate to the community than in any known higher form, hence, there is greater harmony with never a real ruler. Insects were, perhaps, the first forms of animal life to permanently emerge from the primeval sea, and if so they thus have the start of all others in adjusting to new and more complex situations. It is practically certain that they were the first to fly, adding thus a new and even physically larger field of experience.

The natural order of studies of life is first, classification and nomenclature, involving inner anatomical structure, then the study of life histories of individuals, a far more important and intricate work for which taxonomy is merely preparatory and of which we as yet know very little and that only of very few species. Even our acquaintance with terrestrial forms is limited, while of fresh-water and especially pelagic types we have but the slightest knowledge even of the species, the morphology of which is found in our text-books. Very likely many still unstudied are yet more remarkable than the highest yet known.[1]

[1] Daniels, Scudder, Lacoe for years collected fossil insects in this country and lately all those in our national museum were handed over to Professor Handlirsch, of Vienna, who found among them 137 new species, and has classified and located them so far as possible in the successive geological strata, especially those that belong to the coal measure and the Permian Age. Little is known of the horizontal distribution of these insects, but the similarity of the American to the

Thus of the life histories and the evolution of instincts, which ought to be the goal and the key of all, our ignorance is painful. Among the boldest and most important beginnings in this field are the attempts of a few pioneers like Buttel-Reepen, to construct the genesis of the social organization of bees and ants.[1] He thinks division of labor the *primum movens*. First the female hives alone, the male having vanished after the nuptial flight. The nest is of one cell and apart. Here the mother lives and dies alone before the young appear, each from its own hole in the earth. Next the mother finds it easier to give to several cells a common exit, and by thus economizing labor she can lay more eggs. This development was accelerated and the mother continued to lay longer till the first eggs hatch before she is done laying, and mother and offspring meet and the family begins. Some of the young do not fly out at once but help the mother build and provision the last cells. In parthogenetic species the young may even help the mother lay eggs. These individuals may never become fertilized so that they become sterile workers who stay at home while the males rove. Later, as now with wasps and bumblebees, the young female is fertilized in the fall and in the spring builds, and rears a brood, defending them and bringing food. Slowly the mother becomes only an egg layer and very fecund, while the workers lay no eggs, so that as the young and the queen are tended by the workers, each depends upon the other. This view shows how workers are derived from queens, which as opposed to current views that males vary more than any other members of a community. In some ants, besides the normal winged queen, there are often fruitful queens without wings. Workers are thus distinguished of different sizes and with different functions, and a soldier caste arose. Buttel-Reepen even attempts a genesis of the fungus garden of some ants. He found one queen which in several important respects repeated this genetic history, even living peacefully with another queen for a time, till the future colony was assured, then killing it. Quality or quantity of food, and perhaps both, aid in the fur-

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European species is very striking. As a result of comparing the number of forms in the single orders of the Paleozoic Age the paleodictyoptera seem to be the stem group on morphological grounds. It also appeared first and then steadily gave place to the seven more specialized orders, which latter are transitional to modern insects. These seven orders appear in their maximal numbers in the middle beds of the Paleozoic before giving place to the newer forms. Revision of American Paleozoic Insects, by T. R. Proceedings of the United States National Museum, Vol. 29, 1906, pp. 661-820.

[1] Die Stammesgeschichtliche Entstehung des Bienen Staats, Thieme, Leipzig, 1903. Also Wie entsteht die Amiesen-Kolonien. Arch. f. Gesellshafts Biologie, 1905, p. 20.

ther development, polymorphization and the division of labor. The evolution of the ant state, as he describes it, while following a somewhat different course, shows a more elastic organization than that of bees, including as it does aphids, etc., a greater independence of its members, more all-sided adaptation to food and forms of dwelling, and hence it has more power of persistence. Escherich who has studied ants for nearly half a century, thinks many phyletic features can be made out when we compare the over five thousand species and varieties of formicidæ, and holds that the workers with their larger brains have led the way. He believes they were winged at first and that those now so have reverted, Poulton suggests developmental stages for insect mimicry, and derives the wet phase of some dimorphic butterflies from an older dry phase, the two being often so different as to be thought distinct species. Wheeler[1] suggests a phylogeny of parasitisms and the results of mixing members of different nests and races, of slavery, etc. The data in all these cases are comparative and cannot be very firmly based on, or even connected with, paleontology.

For our part we believe the long period of inveterate and incessant disparagement of instinct and even of highly adaptive reflexes as unconscious and automatic and as lacking in the indefinite and very much over prized element of consciousness or discursive reason is passing, and that the future will see an opposite tendency, viz., that modes of life that fit the nature and needs of the species with exactness will be deemed high just in proportion as they have become blind and mechanical and therefore, securely established, and that man would tend to be morally and intellectually better if he did and thought rightly in all important matters as a music-box, when wound up, plays the right tune, with proper expression to the end, however long and complex it is. The superiority of instinct over reason is that it regulates conduct in the interest of the species at every point while consciousness is selfish and is exactly measured by the degree to which the individual has broken away from the dominance of the race and set up for himself against it. This is a disease of our infant race, but it is a grave one that threatens the very attainment of man's maturity. If our venerable animal forbears passed through such a stage of consciousness (as perhaps they did in various degrees when they were young as we are now) without becoming permanently aberrant, and reached their present perfect adjustment or else became extinct in exact proportion as they conformed to their law of life or swerved from it, then the chance of man's renormalization from the fall is perhaps about as grave as all religions make it.

[1] W. M. Wheeler: Nests of Ants. Am. Nat., July, 1903, Vol. 34, pp. 431-513.

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THE TRIDIMENSIONAL THEORY OF FEELING[1]

By E. B. TITCHENER

A lecturer who had expounded Wundt's elementary doctrine of feeling in the year of grace 1893 would have called attention to two principal points: the status of feeling in consciousness, and the number and nature of the affective qualities. Feeling, Wundt says in the fourth edition of the *Physiologische Psychologie*, is a third attribute of sensation, "eine dritte Eigenschaft der Empfindung." "Neben Intensität und Qualität begegnet uns mehr oder minder ausgeprägt in jeder Empfindung ein *drittes* Element . . . Wir nennen diesen dritten Bestandtheil der Empfindung den *Gefühlston* oder das *sinnliche Gefühl*." And feeling or affective tone ranges between qualitative opposites, which "wir als *Lust-* und *Unlustgefühle* bezeichnen." Pleasantness and unpleasantness are the ultimate simple forms of sense-feeling; the irreducible qualities of the pure affective tone which is immanent in the simple sensation. At the same time, the terms 'pleasantness' and 'unpleasantness' are not adequate to describe the affective tone of any and every sensation that we obtain by psychological analysis. The qualities of the higher senses, sight and hearing, play an important part in the compound ideas which appeal to the æsthetic side of our nature. Probably for this reason, their affective coloring is approximately, *annähernd*, identical with that of such compound ideas; they have taken on a *Stimmungscharakter*, "der nicht mehr schlechthin auf Lust und Unlust zurückgeführt werden kann, sondern in andern, in gewissen Affecten deutlicher ausgeprägten Gegensätzen einen adäquateren Ausdruck findet." Tones, *e. g.*, may be grave or cheerful; colors may be calming or exciting. The passage from pure affective tone, pleasantness or unpleasantness, to these æsthetic, emotional shades of feeling may be traced through the series of the senses. Touch and the common sensations show pleasantness-unpleasantness with only a trace of "qualitative Färbung;" tastes and smells are predominantly pleasant or unpleasant, but nevertheless admit of "verschiedenartigere Gefuhlsfärbungen." Tones and colors, which are strongly pleasant or unpleasant to children and savages, have almost lost these attributes for the civilised adult,—though even for us the seriousness of deep

[1] A lecture delivered at Columbia University, Feb. 20, 1908.

tones and of black surfaces leans towards unpleasantness, and the excitement of high tones and of white towards pleasantness, —and have assumed an affective coloring whose general affinity to pleasantness-unpleasantness is, in extreme cases, proved only by its movement between qualitative opposites.

That, then, was Wundt's doctrine, taken at the purely descriptive level: sensations with an immanent attribute of pleasantness-unpleasantness, the original simplicity of which appears clearly enough in the lower sense-departments, but in the higher is obscured by æsthetic or quasi-æsthetic reference.

Now suppose that, as the novelists say, three years have elapsed, and that the same lecturer is discussing the same subject in 1896. He has in his hands the first edition of Wundt's *Grundriss der Psychologie*. And there he reads of "zwei Arten psychischer Elemente, die sich als Producte der psychologischen Analyse ergeben, . . . Empfindungselemente oder Empfindungen [und] Gefühlselemente oder einfache Gefühle." The constitutive attributes ("unerlässliche Bestimmungsstücke) of sensation are quality and intensity. Affection, too, possesses these attributes. But there is a difference. While sensible qualities are limited by maximal differences, affective qualities range between maximal opposites. While the number of sensible qualities is fixed by the differentiation of the sense-organ, the number of affective qualities is indefinitely large; for simple feelings are the subjective complements, not only of simple sensations, but also of compound ideas and of still more complicated ideational processes. And while sensations fall into a number of separate systems, there is but one affective system: tone and color, warmth and pressure are disparate, but "alle einfachen Gefühle bilden eine einzige zusammenhängende Mannigfaltigkeit, insofern es kein Gefühl gibt, von dem aus man nicht durch Zwischenstufen und Indifferenzzonen zu irgend einem andern Gefühle gelangen könnte."

Do, then, all these many affective elements fall within "dem allgemeinen Rahmen einfacher Lust und Unlust?" By no means! There are three *Hauptrichtungen der Gefühle*, three dimensional categories, "innerhalb deren unendlich viele einfache Qualitäten vorkommen." These are pleasantness-unpleasantness, excitement-inhibition or excitement-tranquillisation, and tension-relaxation. As a rule, Wundt says, psychologists have paid regard only to pleasantness and unpleasantness, and have relegated the other two affective classes to the emotions. But as emotions arise from the combination of feelings, the fundamental types of emotion must be preformed, *vorgebildet*, in the affective elements.

In cases like this, I always want to trace the motive. Like the lawyer in *David Copperfield*, I assume that in all such

cases there *is* a motive. What was it, then, that led Wundt to his change of opinion?

If my reading of Wundt is correct, the changes that he has made from time to time in his various systematic works have never been due, in any real way, to external causes, but have always represented the climax or culmination of a stage of internal development. The germs of the changes are invariably, I think, to be found in the prior Wundt, and the changes themselves are but the full and self-conscious maturity of ideas that had long been 'incubated,' had long been held in the obscure margin of consciousness. On the other hand, it is possible, at least in most cases, to point with a fair degree of probability to the external cause that brought these obscure ideas to the attentive focus. In the present instance, that external cause appears, very obviously, in the publication of Külpe's *Grundriss*. Let me be clear on this matter, even if I am repetitious! I believe that Wundt would have formulated his new affective theory in any event; the theory was implicit in him and in his previous writings. If Külpe had not given the touch that led to crystallisation, some one else would, sooner or later, have performed the same office. In fact, however, Külpe undoubtedly did furnish the external stimulus,—so that, indeed, we have to thank him, not only for his own *Grundriss*, but in a certain special and limited sense for Wundt's as well.

Let me take you, now, to the first edition of the *Physiologische Psychologie*, the edition of 1874. In general, the exposition is very like the exposition of 1893. But, in 1893, we are told that the affective tone of sensations of the higher senses is a *Stimmungscharakter*, a coloring that they have 'taken on' in virtue of their constant participation in æsthetic ideas. In 1874, the reference to æsthetics comes at the end of the discussion: the fact that sight and hearing have freed themselves of sense-pleasurableness and sense-unpleasurableness fits them to serve as elements in æsthetic effect. They are not grave and dignified and happy and cheerful because they have been æsthetically employed, but their gravity and cheerfulness are what enables us to employ them with æsthetic result. "Lust und Unlust," Wundt concludes, "sind, wie es scheint, nur die von der *Intensität* der Empfindung herrührenden Bestimmungen, während an die *Qualitäten* Gegensätze anderer Art geknüpft sind, welche zwar zuweilen in eine gewisse Analogie mit Lust und Unlust sich bringen lassen, an sich aber doch von diesen letzteren nicht berührt werden." Here is the doctrine of the plurality of affective dimensions plainer and more definite than it was twenty years later; here is, evidently enough, the germ of the doctrine of 1896.

Once more: the chapter from which I have been quoting is

entitled, in 1893, "Gefühlston der Empfindung,"—in 1874, "Sinnliche Gefühle." Is not that significant also? Affection, in 1874, is not an attribute of sensation; it appears in that rôle for the first time in 1880. Affection, in 1874, is a relation, the relation which sensation sustains to consciousness at large. "Als ein nach Qualität und Intensität bestimmter Zustand ist die Empfindung nur im Bewusstsein gegeben; in Wirklichkeit existirt sie daher auch immer nur in ihrer Beziehung zu demselben. Diese Beziehung nennen wir das sinnliche Gefühl."

Clearly, then, the whole of the new affective theory is implicit in the original edition of Wundt's great work. So far from suddenly reversing his attitude to affective processes, he has, in reality, returned to his first systematic position. In other words, the problem with regard to Wundt is not so much that he now makes affection an independent element with a plurality of dimensions and qualities, as rather that he ever did anything else. This problem, too, can be solved; but it is foreign to our present consideration.

We are to examine, in this Lecture, the theory which I briefly outlined a moment ago on the basis of the *Grundriss* of 1896. The theory has been widely and variously discussed, and I cannot attempt to cover the whole of the relevant 'literature.' I shall refer, for the most part, to the earliest statements of it, in the *Grundriss* of 1896 and the *Vorlesungen* of 1897, and to the latest systematic statement in the *Physiologische Psychologie* of 1902.

First of all, then, how does Wundt arrive at his three affective dimensions? How does he prove that there are three, and that these three are pleasantness-unpleasantness, excitement-inhibition, and tension-relaxation? Well! his main reliance is on his own introspection. Wundt is a man of keen sensibility. He writes of feeling *con amore:* he is fond of quoting Goethe's *Farbenlehre;* feeling has played a larger and larger part in his psychological system as time went on; as early as 1874, he had systematised, thrown into diagrammatic form, his affective reactions to colors and tones. So the new theory appears in the *Grundriss* without preface or apology,—"wird einfach als Tatsache eingeführt," Orth plaintively remarks,—takes its place in the exposition with all the assurance of established fact. Remembering its genesis, its deep rooted and slow growth in Wundt's mind, we need not be greatly surprised. Wundt had said in 1874: "Gelb. . . . regt an, blau stimmt herab;" and had emphasised "das eigenthümliche Gefühl des Aufmerkens" which appears "im Zustande des Besinnens oder der Spannung." No doubt, it seemed obvious to him in 1896 that the introspective evidence, though not expressed, would be understood,—if indeed the thought of expression ever oc-

curred to him. Now, after several years of criticism, he is more explicit; the *Physiologische Psychologie* introduces the theory by way of definite introspective analysis.

Even in the *Grundriss*, however, Wundt is not simply dogmatic. He explains (*a*) that a triple classification of the affective elements is required for the distinction of the fundamental types of emotion. Later on, it is true, he declares that a psychological classification of the emotions "nur auf die Qualität des Gefühlsinhaltes gegründet werden kann." The argument has a circular look; affections are classified by reference to emotion, emotions by reference to affection. I think, however, that it is formally sound. Theoretically, emotions may be classified by quality, by intensity, and by temporal course. In practice, intensity and temporal course fail to furnish reliable criteria: hence, emotions must be classified by quality. Qualitative analysis then reveals certain fundamental types of emotion, which must, of course, be preformed in the affective qualities. Emotive classification thus points us back to a particular classification of affections, while affective classification, to be adequate, must necessarily point forward to emotion. Formally, this reasoning is rather a matter of what Fechner would call the 'solidarity' of a system than an instance of merely circular argumentation. Whether it is materially sound is another question,—a question which Stumpf, *e. g.*, would answer with an emphatic negative.

Wundt also brings evidence of an objective sort, the evidence (*b*) derived from the method of expression. He lays but slight stress on pulse-correlation in the *Grundriss*: "es ist unzulässig die Ausdrucks- der Eindrucksmethode in Bezug auf ihren psychologischen Werth gleichzuordnen." In the *Vorlesungen*, too, the pulse-records are introduced to prove the physiological relationship of the 'lower' to the 'higher' feelings, some time before we reach the distinction of the three affective dimensions. It is not until 1900, in the *Bemerkungen zur Theorie der Gefühle*, that the changes in innervation of heart, vessels and respiratory mechanism — "ein überaus feines Reagens auf die leisesten Aenderungen der Stärke wie Richtung der Gefühle" — are given anything like an independent place in Wundt's argument. Do not fear, now, that I shall plunge you into the technical intricacies of the expressive method, and that the remainder of the hour will be filled with sphygmograph and plethysmograph, pneumograph and dynamograph! Even if that method came into our discussion, I could pass it over with the reminder that, not so long ago, I gave a critical review of it from this platform. But it does not come into our discussion. Grant everything that the most ardent disciples of the method demand, and then ask yourselves: where is the evidence, in these

correlations, that we are dealing with elementary mental processes? What have pulse-curves to say to the question of the irreducibility, the ultimateness in consciousness, of the experiences of excitement-inhibition, tension-relaxation? Wundt himself is careful, in psychological connection, to differentiate "specifische Beschaffenheit" and "elementare Natur." How can pulse aud breathing be relied upon to make the same distinction?

Let us, then, dismiss the expressive method and come back to the *Grundriss*. Had Wundt stopped short at the point which we have now reached; had he stated his theory, shown its usefulness in systematic regard for the classification of emotions, and indicated the correlated differences in the pulse-tracings: his position would, I think, have been stronger than it actually is. But he attempts, further, (*c*) to connect the three dimensions of affection with the three relations in which a given feeling may stand to the temporal course of mental processes at large. Pleasantness and unpleasantness denote a determinate modification of our present mental state; excitement and inhibition exert a determinate influence upon the next succeeding state; and tension and relaxation are qualitatively determined by the preceding state. "Diese Bedingungen machen es zugleich wahrscheinlich, dass andere Hauptrichtungen der Gefühle nicht existiren."

And yet — quality is the criterion for the classification of emotions, and the classification of the emotions requires three ultimate affective dimensions! Here, surely, we have the fallacy of too many proofs. Wundt, it is true, offers in the *Bemerkungen* a defence of his dual argument. "Es handelt sich hier um Momente, die selbst wieder mit einander zusammenhängen" : "[es] kommt hier überall nicht ein Verhältniss von Ursachen und Wirkungen, sondern lediglich ein solches von Beziehungen und Bedingungen in Frage, die sich wenigstens vorläufig durch eine vollständige Analyse aus der Gesammtheit der complexen Bedingungen nicht isoliren lassen." If I understand these passages aright, Wundt's meaning is as follows. 'Consciousness is always exceedingly complex, so that the affective processes are given in complex relations and appear as variously conditioned. Causal analysis is, at present, beyond our powers. We can, however, trace certain relations and follow up certain part-conditions; and our results, different or even incompatible as they may look, are really abstractions from — represent moments of — a single system of causal interrelations. Hence, they may safely be set down side by side.' In the abstract all this may be granted. Still, however, I do not see, in the concrete, how the three affective dimensions can be guaranteed *both* by temporal relations to the course of con-

sciousness *and* by qualitative differences in emotion. The latter are enough, in themselves; the former is, at the best, a matter of reflection, of analysis above the elementary level; and its obvious superfluity tends to cast doubt upon the results of qualitative analysis proper, with which it is brought into agreement. For the rest, it is significant that, in his later writings, Wundt has dropped this principle of temporal relation as a means of affective classification.

In the *Vorlesungen* of 1897 a new principle makes its appearance. After distinguishing the three dimensions of pleasantness-unpleasantness, excitement-tranquillisation, tension-relaxation, Wundt says: "dass es noch andere Hauptrichtungen ausser diesen gebe, scheint mir nach der subjectiven Beobachtung nicht wahrscheinlich. Auch dürften die genannten den allgemeinsten Bedingungen entsprechen, unter denen Gefühle überhaupt entstehen." The dimensions are guaranteed first by introspection, and secondly (*d*) by the threefold character of affective conditions. The conditions are found in the "Empfindungs- und Vorstellungselemente, an die [die Gefühle] gebunden sind." Pleasantness-unpleasantness represent a quality-dimension; excitement-tranquillisation, an intensity-dimension; tension-relaxation, a time-dimension. "Die Bedeutung von Lust und Unlust als 'Qualitätsrichtungen' liegt darin, dass vorzugsweise in ihnen die Wirkungen der qualitativen Eigenschaften des gesammten Bewusstseinsinhalts zum Ausdruck kommen:" and similarly with the other two dimensions. Intrinsically, of course, every affection is a quality, qualitatively different from every other. But the affective qualities of the three dimensions reflect, express, are determined by the quality, intensity and temporal properties of sensations and ideas.

I am not here concerned with the correctness or incorrectness of Wundt's correlation. He has himself changed it, in the *Physiologische Psychologie* of 1902, where pleasantness-unpleasantness represent an intensive, and excitement-tranquillisation a qualitative dimension,—just the reverse of what was said in 1897. I am concerned with the correlation as a principle of classification. There are, Wundt declares, three general conditions of the arousal of feeling: the quality, the intensity and the temporal relations of conscious contents. And the threefold character of the conditions furnishes, along with introspection, evidence that there are but three dimensions of affection. What, then, has become of the spatial relations of conscious contents? The chapter-headings of the *Physiologische Psychologie* tell us that *Sinnesvorstellungen* are of three kinds: intensive, spatial, temporal. Spatial and temporal ideas may be grouped together as extensive; intensive ideas

differ from sensations by the composite nature of their intensity and quality. These intensive ideas are therefore responsible for two affective dimensions, the intensive and qualitative; the temporal ideas are responsible for a third dimension, the temporal; only the spatial ideas are excused from affective duty. I argue, then, in this way. In so far as affective classification is dependent upon the various forms of idea, in so far Wundt's classification is inadequate: for the spatial form of idea is as important, in the mental life, as the intensive or the temporal. And if there is no such thing as a spatial dimension of affective qualities, then we may justly doubt whether the principle of classification is sound, and whether any conclusion as to the number of affective dimensions may be deduced from it. Remember, I am not arguing on a matter of fact; I am disputing the application of a principle.

Wundt replies, in the *Bemerkungen*, that he has left spatial ideas out of account for two reasons: first, "weil sich mir Beziehungen derselben zu bestimmten Gefühlsrichtungen weder in der unmittelbaren subjectiven Beobachtung noch bei der Analyse der Ausdrucksbewegungen darboten;" and secondly, "weil es mir scheint, dass man sehr wohl bei jedem Affect qualitative, intensive und zeitliche Eigenschaften unterscheiden kann, während ich mit dem Ausdruck, der Zorn oder die Freude habe irgend eine räumliche Ausdehnung, keinen rechten Sinn zu verbinden weiss." The first of these arguments misses its mark for the reason that, in the *Vorlesungen*, the distinction of three general conditions of feeling, their connection with three forms of idea, is offered as *additional* evidence, over and above 'subjective Beobachtung,' for the finality of Wundt's classification. "*Auch* dürften die genannten Hauptrichtungen den allgemeinsten Bedingungen entsprechen unter denen Gefühle überhaupt entstehen." I object to Wundt that the one of his criteria is invalid, and he rejoins that the other is valid! The second argument goes equally wide. I did not assert that an emotion possesses spatial attributes, that an affection may be 'extended,' but that certain ideas possess spatial attributes and relations,—and that, if we are classifying affections by reference to the forms of ideas, then these spatial properties must be taken into account, as well as the intensive, qualitative and temporal. I use the phrase 'spatial dimension of affective qualities' precisely as Wundt uses the phrase 'temporal dimension,'—to signify affective qualities that are dependent upon ideational extension. I acquitted Wundt, just now, of the charge of circularity; I am afraid that I must here charge him with the logical error which is known in the vernacular as 'missing the point.'

In sum, therefore, Wundt's three affective dimensions are

supported, primarily, by his own introspection, while he has appealed, further, to the necessities of emotive classification; to the results of the method of expression; to the temporal relations of the affective processes; and to their general conditions in consciousness. The first of these arguments I take to be sound, both formally and materially, though I do not arrive by it at the conclusion which Wundt has reached. The second must be pronounced irrelevant; the third has been given up by Wundt himself; the fourth we have seen to be logically defective and psychologically indefensible.

We have now to consider the theory on the basis that remains for it: introspection of the simple sense-feelings and qualitative analysis of the emotions. I find a difficulty at the outset, in Wundt's terminology. You may have been surprised that when I have had occasion to mention Wundt's category of 'excitement,' I have paired it with 'inhibition' or 'tranquillisation,' rather than with the more usual term 'depression.' I have throughout been quoting Wundt's own words, but it is true that in the *Grundriss* 'depressing' is given as an alternative to 'tranquillising,' and that in the *Physiologische Psychologie* 'Depression' is suggested for the higher degrees of 'Beruhigung.' Wundt can, of course, do no more than take language as he finds it. But I think that his actual choice of words bears witness to a conflict, in his thought, between two purposes: the purpose of transcribing his introspections, and the purpose of maintaining the typical affective movement between opposites. Pleasantness and unpleasantness, *Lust and Unlust* are opposite in name, as well as in nature. What of *Spannung* and *Lösung?* In English, 'relaxation'—which, I suppose, is the nearest equivalent of *Lösung*—suggests rather the remitting or resolving of tension than its qualitative opposite: this latter would be better expressed by 'relief.' Possibly *Lösung* has for Wundt an implication of positive relief, of *Erleichterung*,—though it has not for me, nor for German friends of whom I have made enquiry. Wundt speaks also of the *Befriedigung*, the fulfillment, of expectation; but that term brings us perilously near to *Beruhigung*. The chief difficulty, however, arises in connection with the remaining dimension. What is the opposite of *Erregung?* Sometimes Wundt says *Hemmung*, sometimes he says *Beruhigung*, sometimes *Depression*. The antithesis *Erregung-Hemmung* comes from nerve physiology; *Erregung-Depression* comes, evidently, from observation of the emotions, normal and pathological; *Erregung-Beruhigung* appears to be the analogue of *Spannung-Lösung* and to convey the same suggestion. But what is in introspection the *felt* opposite of *Erregung?* I cannot myself identify the feelings of *Hemmung*, *Depression*, *Beruhigung;* I

cannot feel them as degrees of the same thing, as lying in the same affective dimension; I cannot always distinguish between *Beruhigung* and *Lösung*. *Erregung*, 'excitement,' seems to me to feel very differently in different contexts, to be an equivocal term. It is easy to say that such considerations are mere 'Wortklauberei,' but I am trying to express a real introspective difficulty.

If, then, I am to judge others by myself, this uncertainty in the meaning of terms may be at least a partial reason for the fact that Wundt's classification, despite its claim to finality, does not always command the assent even of those who agree with its spirit and intention. Gurewitsch, *e. g.*, in his *Theorie der sittlichen Gefühle*, makes a fourth affective category for *Streben-Widerstreben*. Vogt, again, ranges feelings of activity and passivity alongside of pleasantness-unpleasantness, arousal-depression, tension-relaxation. Wundt identifies *Strebungsgefühl* with *Thätigkeitsgefühl*, and makes it a total feeling, compounded of strain and excitement. Royce, on the other hand, is disposed to think that two dimensions — pleasantness-unpleasantness and restlessness-quiescence — are adequate to the facts of the affective life. I do not at all mean that these differences of opinion are fatal to the theory. But they testify—do they not?— to a lack of precise formulation. Royce throws two of Wundt's dimensions into one; Vogt and Gurewitsch split the same two into three.

The single dimension about which Wundt himself seems, from the first, to have felt no doubt is that of *Spannung-Lösung*. The other two dimensions, as I pointed out just now, have actually exchanged places in his system. And the same uncertainty characterises certain of his observations in detail. Let me give you an instance. In the Bemerkungen of 1900, Wundt writes: "ich wüsste . . . wenn ich vor die Wahl gestellt wäre, irgend einen dieser Eindrücke dem andern vorzuziehen, absolut nicht zu sagen, ob mir das rein spektrale Blau oder das Roth . . . angenehmer sei." This does not mean that the two colors would be equally pleasant. "Ich würde eben einem solchen Verlangen immer nur die Aussage gegenüberstellen können, dass diese Eindrücke an sich mit Lust und Unlust nichts zu thun haben." The passage is a little startling, when one remembers that work had already been done upon colors—and colors that were not spectral colors —by the method of impression! Two years later, now, we have the following: "wenn ich zuerst ein spektralreines leuchtendes Roth und dann ein ebensolches Blau im Dunkelraum betrachte, so kann ich nicht umhin, beide als im hohen Grad erfreuende, also lusterregende Eindrücke zu charakterisiren." True, the sentence is concessive; the next begins with a

'gleichwohl;' but it is, nevertheless, in flat contradiction to the former quotation. If two impressions are highly pleasant, they *can* be compared as regards pleasantness, and a judgment of greater, less or equal can be passed upon them. Similarly conflicting statements are made concerning high and low tones. I readily acknowledge, again, that these minor inconsistencies are in no sense fatal to the theory; indeed, Wundt has so often emphasised the importance for feeling of the "ganze Disposition des Bewusstseins" that I feel reluctant, as it were a morsel ashamed, to dwell upon them. Still, they are there! And it is not reassuring to find that the dimension *Spannung-Lösung* owes its exceptional position, the stability of which I spoke above, to its systematic connection with the doctrine of apperception. It must have occurred to many of you, when earlier in the Lecture I was arguing the claims of space as a condition of feeling in consciousness, to ask—what, then, after all, are the claims of time? Since, in the psychology of sensation, duration and extension are, both alike, to a very large extent equivalent to, interchangeable with intensity, why should they not be bracketed with intensity as the conditions of one and the same affective dimension? We should then have something like Royce's classification: pleasantness-unpleasantness, conditioned upon all the 'qualitative' attributes of sensation, and excitement-quiescence conditioned upon all the 'intensive.' Now Wundt recognises the equivalence, under certain circumstances, of intensity and duration. "Insbesondere kann die Lust-Unlustcomponente [bei längerer Einwirkung auf das Bewusstsein] ganz dieselben Veränderungen erfahren, die auch die Steigerung der Intensität mit sich führt." But feelings of *Spannung* and *Lösung* are "die specifischen, für die Aufmerksamkeitsvorgänge charakteristischen Elemente." "Da aber Apperception und Aufmerksamkeit zeitlich sich entwickelnde Vorgänge sind, die zugleich in einer bestimmten zeitlichen Folge wechseln, indem jede Lösung eine vorangegangene Spannung fordert, und eine neue Spannung wiederum nur auf Grund vorangegangener Lösungen einsetzt, so sind diese Gefühlscomponenten enger als die übrigen an den zeitlichen Ablauf der Bewusstseinsvorgänge gebunden." Any serious doubt, therefore, about Wundt's doctrine of attention and apperception must at the same time jeopardise this third dimension of simple feeling.

So far, I have spoken only of the three affective dimensions; I have said nothing of the multitude of elementary qualities which the dimensions are held to include. "Die qualitative Mannigfaltigkeit der einfachen Gefühle ist unabsehbar gross und jedenfalls viel grösser als die Mannigfaltigkeit der Empfindungen." So the *Grundriss*,—which proceeds to give two

reasons. First, every sensation of the multidimensional sensation-systems belongs to more than one affective dimension. Secondly and more importantly, the feelings that attach to sensation-complexes, intensive, spatial and temporal ideas, and to certain stages in the temporal course of emotion and volition, are nevertheless themselves irreducible, and must therefore be counted among the elementary affective processes. You will notice that these reasons are phrased in the language of a special psychological system, though the appeal to introspection is implied. Later on, the appeal becomes explicit; we are reminded that, *e. g.*, the feeling of gravity, *Ernst*, "in verschiedenen Fallen in seiner Qualität wieder variiren kann." In the *Vorlesungen*, the doctrine of the multiplicity of affective qualities follows naturally from the doctrine of the *Totalgefühl*. The *Physiologische Psychologie* relies upon an 'aufmerksame Selbstbeobachtung.' We are apt to overlook the great variety of the feelings, partly because they are intimately bound up with the objective contents of consciousness, partly because we have no words to express them. "Angesichts der [an der Hand des vergleichenden Verfahrens der Eindrucksmethode] ausgeführten Analyse scheint es mir in überwiegenden Masse wahrscheinlich, dass die sechs Grundformen . . . eben nur *Grundformen* sind, von denen jede einzelne eine sehr grosse Mannigfaltigkeit im ganzen verwandter, aber dabei doch von Fall zu Fall nuancirter Einzelgefühle unter sich begreift."

There can be no manner of doubt that, in this matter of the number of the affective qualities, the psychological pendulum has been swinging, of recent years, in the direction that Wundt has taken. Ladd emphatically repudiates the view that "'pleasure-pains' are exhaustive of the entire quality of the feeling-aspect of consciousness." The theory is simplicity itself: "but simplicity, in the interests chiefly of biological and experimental psychology, 'gone entirely mad.'" I do not know whether Ladd felt pleased or pained that he had written this last sentence, when two years later he read Wundt's *Grundriss*. He says himself, however, that "almost all mental states which are marked by strong feeling in the case of developed minds are *mixed* feelings." At any rate, he works resolutely through the sense-departments, in 1894, and makes out a long list of elementary processes. James, in the same year, remarks that "there are infinite shades and tones in the various emotional excitements, which are as distinct as sensations of color are, and of which one is quite at a loss to predicate either pleasant or painful quality." This position is, of course, entirely compatible with a dual view of *Lust-Unlust*, of "the primary *Gefühlston*:" indeed, the two doctrines seem to me to appear, side by side, in James' own exposition. Nevertheless,

the passage may fairly be cited in the present connection. Lipps, again, working as it were from the opposite pole to Wundt, has arrived, as we all know, at a very complicated classification of the feelings. Stumpf has expressed the opinion, as against Külpe, that "sinnliche Annehmlichkeit" and "sinnliche Unannehmlichkeit" cover "eine grössere Mannigfaltigkeit von Gefuhlsqualitäten." This array of convictions is imposing, even if there are authorities—Höffding, Külpe, Jodl, Ebbinghaus, Lehmann, Rehmke—upon the other side.

The fact is, of course, that the ultimate question of a previous Lecture, the question of the criteria of affection, has not been settled. The parties to the present controversy do not really 'feel' differently; but they approach the problem with a certain attitude towards affective process, with a certain general view of the status of feelings in consciousness. Ebbinghaus says outright that Wundt and Jodl, *e. g.*, are 'not talking of the same things.' Orth believes that Wundt's theory is the outcome "seiner ursprünglichen Auffassung des Verhältnisses zwischen Empfindung und Gefühl." Ladd writes with a sort of ethical, even religious, atmosphere upon him: how can you compare the pleasure of cheese and beer with the pleasure of seeing a good *Hamlet?* Lipps considers the feelings as modes of reference to the self; feelings are "Ichinhalte oder Ichqualitäten." Stumpf adopts a sensationalist view of the sense-feelings; and in sensation qualitative differentiation is obvious enough. James is concerned with the varieties of emotive experience, and his protest against the 'hackneyed psychological doctrine' that pleasure and pain are the essence of emotion comports, as I have pointed out, with a strictly dualistic view of the affective qualities proper. It is not that our affective experience is radically different, but that we approach it from different directions, see it under different angles, assimilate it in terms of our systematic associations.

I do not mean that the point at issue is a mere *Etikettenfrage*. It is much more than that. Our decision 'makes a difference,' as the pragmatists say, to the whole structure of our psychological system. And it must be remembered that Wundt does not acknowledge any other methods than those employed by the dualists, and would not acquiesce in the statement that his results are of another order. He comes within our universe of discourse; he invites argument. I therefore proceed to argue: and I take as ground for argument an illustration which he employs on more than one occasion,—the feeling which attaches to the common chord *c-e-g*.

Let me remind you, first, of Wundt's doctrine of the *Totalgefühl*. A compound feeling, a feeling due to the confluence of a number of elementary feelings, is always psychologically

simple in the sense that it has its own irreducible quality, but may also permit the distinction of its various components. "In jedem derartigen Gefühl lassen sich *Gefühlscomponenten* und eine *Gefühlsresultante* unterscheiden." The components Wundt terms 'partial feelings,' the resultant, 'total feeling:' we have had an instance already in the 'feeling of activity' which results from the compounding of tension and excitement. The compound feeling thus bears a close resemblance to the formation which, in the sphere of tonal sensation, is called a fusion; Wundt speaks, in the *Physiologische Psychologie* of 'affective fusions.' There are degrees of affective, as there are degrees of tonal fusion; the partial feelings may appear simply as an undifferentiated coloring of the resultant, or may maintain their individuality, though in a subordinate position, alongside of the total feeling.

After this preface, we are ready to listen to the three tones. To prevent a swamping of the partial feelings by the total feeling,—the highest degree of affective fusion,—we take the tones separately in succession, and observe how they 'feel' in isolation. The tone *c*, heard by itself, affects us, Wundt says, by way of a 'calm seriousness' or a 'quiet cheerfulness;' it brings out feelings of two dimensions, pleasantness-unpleasantness and excitement-tranquillisation. The other two, *e* and *g*, will do the same,—though the affective qualities will be somewhat different. If, now, we put the tones together in pairs, every pair will give us a compound feeling: we have the three total feelings of *ce*, *eg*, *cg*, accompanied or colored by the partial feelings which we have compounded. And if the conditions are favorable for observation, we should be able to distinguish a fivefold feeling in connection with every pair; the two dimensions of the two partial feelings, and the total feeling. Now let us sound all three tones simultaneously. We have the total feeling of *c-e-g;* we have three relative total feelings, or 'partials of the second order,' as Wundt calls them,—the feelings of *ce*, *eg*, *cg;* and we have the 'partial feelings of the first order,' the six elementary feelings aroused by *c*, *e* and *g*. The feeling of *c-e-g* is a tenfold complex. Do not forget that such a feeling is, for Wundt, an "einheitliche Mannigfaltigkeit;" do not forget that the partial feelings may, more or less completely, have forfeited their independence. But, with all allowance made, ask yourselves if you experience anything like the body of feeling that, on Wundt's theory, you 'ought' to experience. Suppose that, in spite of our precautions, affective fusion has reached its highest degree; let the partials of the first order disappear altogether, as separate components, and let them remain only as a vague coloring of the whole affective impression. Now your compound feeling should be a

fourfold complex. Surely, it is not: surely, the feeling lacks the depth, the solidity, that a feeling thus compounded must possess: surely, you can describe the chord in no other terms than 'slightly pleasant,' 'moderately agreeable.'

I think that it is fair to test the theory in this way, by the judgment of a group of psychologically trained observers, seeing that Wundt has laid the observation before the psychological public in two of his books. I have, for myself, repeated the test often and again, and have varied it in half a dozen ways: always, while the chord remains a single impression, a sensible fusion out of musical setting and so far as possible freed from musical significance, I get the same meagre affective results.

If, now, Wundt retorts that in this and like instances we are feeling-deaf and feeling-blind, may we not suggest, on our side, that he is organically anæsthetic? The lack of interest that Wundt shows in the organic sensations has always been a source of wonderment to me. Take the new edition of the *Physiologische Psychologie*. Here is a total of 2,035 pages. Of these 45 are given to *Tast- und Gemeinempfindungen;* the *Gemeinempfindungen* alone, which I now have principally in mind, receive four, two and a half of which are devoted to pain. Of course, there are all sorts of scattered references. But look in the index under *Organempfindungen*, *Gemeinempfindungen*, *Niedere Sinne*, *Gelenkempfindungen*, *Muskelsinn*,— what you can think of. Aside from *Bewegungsempfindungen* and *Augenbewegungen* there is surprisingly little. Meumann makes a similar complaint with regard to Nagel's *Handbuch*. "Vermisst hat der Referent, dass den inneren Empfindungen (Organempfindungen) kein ausführlicheres Kapitel gewidmet wird; die gegenwärtige Physiologie scheint sich mit der Frage der Sensibilität der inneren Organe nicht mehr viel zu beschäftigen." Now I personally believe that the organic sensations play an important part, not only in feeling and emotion, but in many other departments of the mental life: in the formation of sensory judgments, in the mechanism of memory and recognition, in motives to action, in the primary perception of the self. It is true that, as compared with what we know of sight and hearing, our knowledge of the organic sensations is scrappy in form and small in amount; that is why I have said, in another connection, that "of all problems in the psychology of sense which are now before us, the problem of the nature, number and laws of connection of the organic sensations appears to me to be the most pressing." Let me add, now, that if any one of you is thinking of a piece of work in this general field, he would do far better, in my opinion, to start out from the side of the organic sensations than to succumb to the fascinations of pneumograph and sphygmograph.

Well! I believe that organic sensations are responsible for the dimensions of excitement-depression and tension-relaxation. On this point I can claim the support of Ebbinghaus and, I suppose, of all those who accept the James-Lange theory of emotion.

Stumpf, too, declares that he cannot regard them as "Elementarerscheinungen," though he offers no further analysis. But I believe, also, that organic sensations are responsible in certain cases for a *Nuancirung*, a shading and coloring, of feelings in the dimension of pleasant-unpleasantness. I say 'in certain cases,' for two reasons. First, it is entirely possible that this *Nuancirung* is a matter, not of simple sense-feeling, but of association, of emotive residua. Secondly, however, I do not think that the coloring and shading is as universal as Wundt asserts. Vogt, whose method of suggestion led him to the distinction of four pairs of feelings, is unable to discover it. Orth cannot find it, in the introspections that he educes by the *Reizmethode*. Störring's observers, on the other hand, report a qualitative difference between *Stimmungslust* and *Empfindungslust;* but though this is, so to say, a gross difference, the expressions used are singularly disappointing. We read, in some detail, of extensive differences, differences in intensive fluctuation, differences of excitement and passivity; but on the side of quality we have only "Stimmungslust ist gleichartiger," and the dogmatic statement "Zwischen Stimmungslust und Empfindungslust besteht *qualitative* Differenz." I, myself, have never observed a qualitative differentiation of pleasantness-unpleasantness, under experimental conditions; and when I observe a difference in everyday life,— a difference on the level of the sense-feeling,— I seem to find a reason for it in concomitant organic sensations.

I have sought, on two occasions, to put Wundt's theory to an experimental test. The method employed was the method of impression, in Cohn's form of paired comparisons. The procedure, in brief, is as follows. A series of stimuli—tones or colors or rhythms—is laid out, and the stimuli are presented to the observer two at a time, care being taken that every member of the series is paired with every other member. The observer has to decide which of the two stimuli shown him is the more pleasant, the more unpleasant, the more exciting, the more depressing, and so on. If colors are exhibited, he points to right or left, as the case may be; if tones are used, he notes down '1' or '2,' according as the first or the second stimulus is preferred. The work is laborious, and the method consumes a large amount of time. We have, however, the great advantage of a twofold control, objective and subjective.

The subjective control is afforded, of course, by the intro-

spection of the observers. The introspective task is extremely simple; the observer has merely to be passive, to let himself go, to allow the stimuli to take affective possession of him; and then to indicate, in the particular instance, which of the two makes the stronger impression. Moreover, since the introspective experience within a series is cumulative, all of the same kind, the observer is able, in the intervals between successive series, to give a general account of his method of judgment, of the nature of his affective reaction. The objective control is afforded by the course of the affective judgments themselves. If, *e. g.*, pleasantness and unpleasantness are really affective opposites, then the 'curves' or tracings which indicate the distribution of judgments in parallel, 'pleasant' and 'unpleasant' series, should be diametrically opposed: a color which stands high on the scale of pleasantness should stand low on the scale of unpleasantness, and contrariwise. If excitement-depression and tension-relaxation also denote affective opposites, then their 'curves' should be similarly opposed.

The stimuli chosen were colors, musical tones, and groups of metronome beats given at varying rates. The two former had been specified by Wundt as productive of excitement-depression, the latter as productive of tension-relaxation. My idea was, on the subjective side, to test by their means the immediacy of reaction in these dimensions. In the case of pleasantness-unpleasantness, you cannot say what the basis of your judgment is, otherwise than that it resides in the stimulus; the one of two colors or two tones *is* more pleasant than the other, just as directly as it is bluer or louder. Suppose, then, that colors and tones bring out equally prompt and unmediated judgments of excitement-depression, and that metronome intervals bring out equally prompt and unmediated judgments of tension-relaxation: then we shall have some ground for the acceptance of the two new affective dimensions. Suppose, on the other hand, that the judgments of excitement and tension are forced or difficult, mediated by associations or by organic sensations: then we shall have an introspective differentiation of these judgments from those of pleasantness-unpleasantness.

On the objective side, I argued in much the same way. Suppose that the curves, of which I spoke just now, show typical differences,—so that the distribution of judgments of pleasantness takes one course, that of judgments of excitement another, and that of judgments of tension a third,—while still the curves of pleasantness and unpleasantness, of excitement and depression, and of tension and relaxation are related as opposites: then, again, there will be ground for the acceptance

of Wundt's dimensions. Suppose, on the contrary, that the curves of excitement and of relaxation agree with the curve of pleasantness, and the curves of depression and of tension with the curve of unpleasantness: then, since the pleasant-unpleasant dimension is not in dispute, we have a strong indication that that alone is fundamental, and that the other two dimensions are affective only because and in so far as pleasantness and unpleasantness are involved in them.

The results of the first investigation, in which colors and musical tones were tested for pleasantness-unpleasantness and excitement-depression, and metronome intervals for pleasantness-unpleasantness and tension-relaxation, were published in the Wundt *Festschrift;* those of the second, in which the same tones and intervals were tested for all three of the Wundtian dimensions, were published by Hayes in the *American Journal of Psychology*. They may be summed up under three headings.

(1) Judgments of pleasantness and unpleasantness are direct, easy and natural. The qualities themselves appear to the observers to be simple and homogeneous, identical throughout the experiments. Their opposite character is vouched for both by introspection and by the course of the curves.

(2) Judgments of excitement are less direct, and the term is equivocal. If it is taken as the opposite of depressing melancholy, its curve agrees with that of pleasantness; if it is taken as the opposite of tranquility or soothing calm, its curve agrees with that of unpleasantness: the reverse curves then agree with those of unpleasantness and of pleasantness, respectively. If, in default of special instruction, the observer vacillates between the two meanings of the word, the curve shows a vacillating character, partly 'pleasant' and partly 'unpleasant:' the period and nature of the affective oscillation are vouched for by introspection. Judgments of depression are, in their turn, distinctly less direct than those of excitement, and are often associatively mediated. There is no evidence of a dimension of excitement-depression, and none of a number of exciting and depressing qualities.

(3) Judgments of tension are easy, but tension is described throughout in kinæsthetic terms. Increasing tension means, uniformly, increasing unpleasantness, and the curves of the two classes of judgment correspond. Relaxation may be taken as the opposite of unpleasant tension, in which case its curve agrees with the curve of pleasantness, or may be identified with depression. Nowhere is there evidence, in this third case either, of a new affective dimension or of specific qualities.

Of course, these results are not 'conclusive.' For one thing, the experiments are too few. For another, they were obtained in a single laboratory, and that a laboratory from which criti-

cism of Wundt's doctrine had already proceeded. For a third, the argument upon which the experiments rest is not demonstrably valid. It would, I think, be a very strange thing if three sets of stimuli should affect a number of observers by way of excitement-depression (or tension-relaxation) precisely as they do by way of pleasantness-unpleasantness,— but nobody can prove that such a state of affairs is, on the plural theory, impossible. Were I a champion of affective plurality, I should unhesitatingly urge these objections to the work, and I have no desire to slur them over because I am on the other side. Nevertheless, the results are experimental evidence: Wundt cannot, in the future, appeal to the method of impression as confidently as he has appealed in the past. And if our investigations are compared with those of Brahn and Gent, upon which Wundt relies in the *Physiologische Psychologie*, it will appear, I am very sure, that the critical sauce meted out to the goose must be considerably strengthened for the gander.

If now, in conclusion, I may give, with all due modesty, my own reading of the situation, it is this: that Wundt's tridimensional theory of feelings shows, as it were in typical form, the peculiar features that distinguish his psychology at large. Wundt has, in an eminent degree, the power of generalisation, and his generalisations cover—as generalisations oftentimes do not—an encyclopædic range of detailed knowledge. But the exercise of this very power leads him to put a certain stamp of finality upon his theories, as if questions were settled in the act of systematisation. You know what I am thinking of: the theory of space perception, the theory of attention, the definition and demarcation of psychology itself. The affective theory which we have been discussing is typical, then, both for good and for bad. It is good, in that it gives rounded and complete expression to a psychological tendency that, in many minds, has been struggling for utterance. It is bad, in that it offers a solution, ready made, of problems which in actual fact are ripe only for preliminary and tentative discussion. Like those other theories of attention and of space perception, it represents the culmination of an epoch of psychological thought; but, like them again, it is rather the starting point for further enquiry than the statement of assured psychological result. On the whole, I take it as matter of encouragement that generalisation has been at all possible. What has been done, provisionally, at a lower level of knowledge, can be done again, and better done, at a higher. In the meantime, we must not be dogmatic, we must not be too impatient for results, we must not set theory above observed fact: recognising to the full the difficulty and the merit of constructive effort, we must use all the weapons in our critical armory against ourselves as against others, and against others as against ourselves.

THE DAILY LIFE OF AMŒBA PROTEUS

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The purpose of the investigation described in this paper was to determine the events in the daily life of *Amœba proteus*—its periods of rest and activity, its reactions to foods and other natural stimuli in its surroundings, how it lives and what it does.

The investigation was made by watching continuously for six days and five nights several amœbas and keeping careful records of their activities. One amœba was followed with special care, while several others under various conditions as to food were also observed continuously during this period, and daily for several weeks following. The amœbas were kept under as nearly natural conditions as possible, and there was every indication that their lives under the microscope were normal. The investigation was made in the Biological Laboratory of Clark University during the winter of 1905-6, under the direction of Professor Hodge. The continuous observations were maintained in relays by Drs. Hodge, Dellinger and the writer.

FIG 1.

The amœbas were kept in a special slide, consisting of a long cover-glass resting on two glass strips cut from an ordinary slide. A drop of water containing the amœba, when inserted between the slide and the cover-glass, clung to both by capillary attraction and made a perfect cell, open to the air, admitting freely of the insertion of pipette, needle, or additional water or food. The cells, when not under observation, were placed in a covered glass jar to prevent evaporation. The amœbas in one cell in this way were kept under daily observation during a period of eight weeks.

The question of the behavior of amœba is not a new one. The movements of no one animal have been studied so repeat-

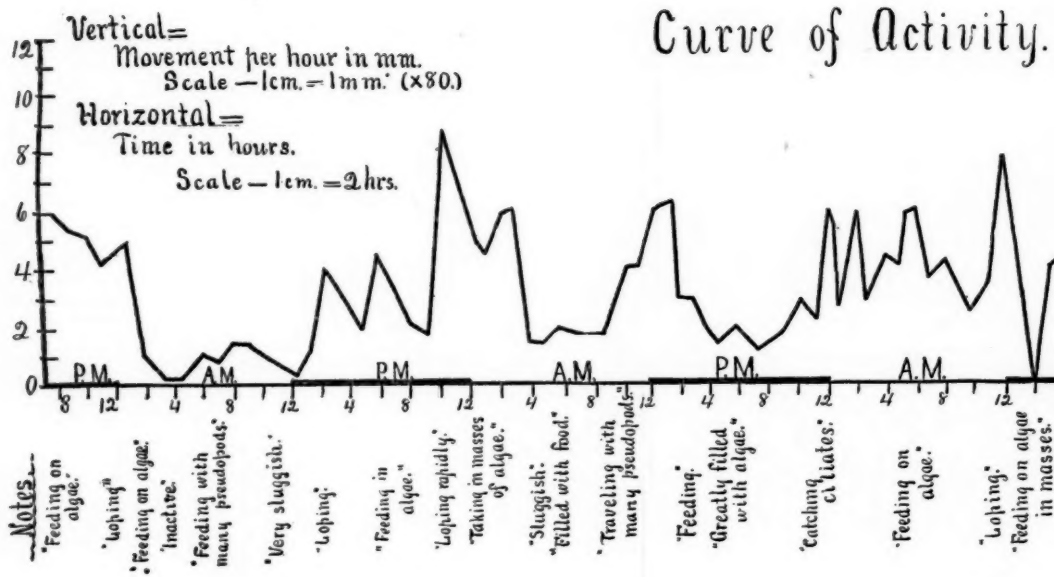

FIG. 2.

By "loping" is meant alternate lengthening and shorteni

ivity.

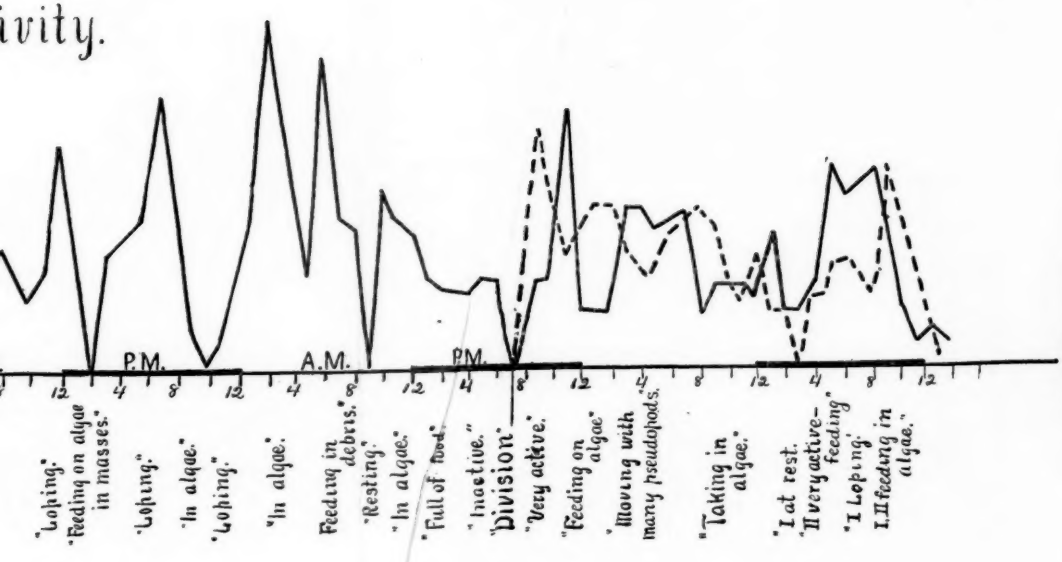

FIG. 2.

nd shortening of the body as a whole without pseudopods.

edly, so carefully, for so many years, and so frequently referred to as those of the amœba. College courses in biology, zoölogy, and some important branches of these sciences find it convenient to start with the amœba. The amœba is basal in biological and physiological theory as a key to the functions and general activities of protoplasm. "Amœbic" and "amœboid" are common terms in scientific literature. The amœba figures in discussions of immortality, heredity, and death. Further, because of the amœbe's apparently simple structure, attempts to produce life artificially have been largely in imitation of the amœba, and it has been connected with "primordial slime" as probably the first animal to be developed. All these indicate how important, even fundamental, is the life history of this animal for the sciences concerned with the theory and development of life.

Throughout the animal series in general the activities of *search for food* and the *rhythm of work and rest* are basal. Success in search determines the life of the individual and of the species to a very large extent. Search is illustrated in all degrees in the life series from the gradual explorations of the root tips of plants to the complex activities of man. The rhythm of work and rest is a necessity imposed by the nature of protoplasm. It is illustrated in all degrees of rest from mere cessation of activity to profound slumber and hibernation. This rhythm is closely connected with effort in search and the attainment of food. For the higher animals this rhythm is necessary for life, but it has been doubted whether it is necessary or is exhibited in the life of the protozoa. The answer to this question is very important in its physiological bearings.

The investigation here briefly summarized showed very definitely that *amœba proteus* does have periods of activity and of rest as reactions connected with search for, and attainment of food. These periods apparently have nothing to do with light or darkness, day or night. The amœba moves actively feeding until well filled with food when it remains quiescent for a time.

These general facts are shown by the curve opposite, which represents the measured activity of an amœba during four days and nights, up to division, and the activity of the parts for two days and nights thereafter.

The curve shows the amount of movement. During the observations the movements of the amœba were measured by the micrometer gauge. At the same time careful notes were taken of the activities of the amœba. Quotations from these notes are placed below the curve and serve largely to explain it. Together they show fairly clearly that a period of activity and feeding was followed by a period of cessation of general move-

ment, and often of apparently complete rest, that the greatest activity was immediately following a period of rest, that the degree and length of rest were in proportion to the degree and length of activity, that the rhythm of activity and rest was most pronounced during the twenty-four hours before division, that during the twelve hours before division the amœba was less active, and divided when at rest, that the parts immediately after division were very active and maintained a high level of activity during the two days in which they were observed.

The greater activity of the parts after division is also definitely shown in the following cuts which represent the actual paths travelled by, first, the amœba before division, and, second, by the parts after division.

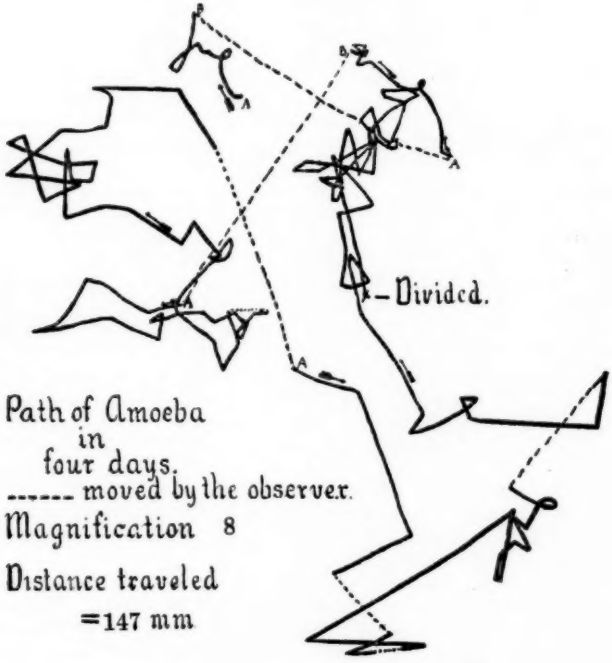

FIG. 3.

This diagram (Fig. 3) shows that the amœba travelled 147 millimeters during the ninety-six hours preceding division, while the following diagram shows that after division one part travelled 45 mm., and the other 52 mm. in thirty-one hours.

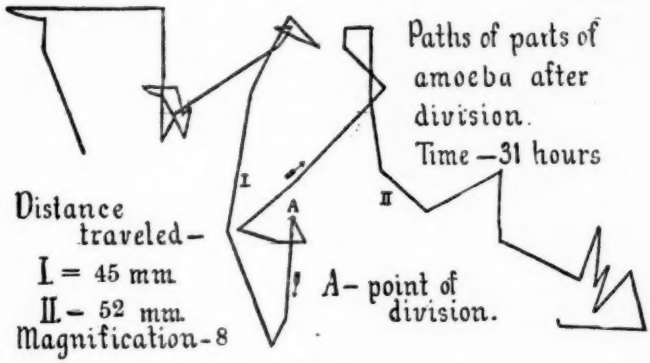

FIG. 4.

The amount of activity is also related to the amount and the kind of food. The amœba observed above was feeding mainly on unicellular algæ and was disturbed only occasionally by ciliates. When feeding on algæ scattered in the field, the amœba was more active than when feeding in a field of abundant supply. In either case it was necessary, however, for the amœba to move about to get its food.

On the other hand, amœbas, which were feeding on ciliates, when these were numerous, moved comparatively little and at long intervals of time, but when the ciliates were less numerous the amœbas were again more active.

The following curves (Fig. 5) show the activities of two amœbas feeding on ciliates. They were observed continuously for sixty-six hours. In the first place it will be observed that the activity was greatest during the first part of this period and became less and less. This was apparently the result of an increase in the number of ciliates in the cells. The necessity for action became less and less. A comparison of this curve with the curve of activity above (Fig. 2), which is on the same scale, shows strikingly this relation of movement to the food. The same fact is also even more strongly illustrated by a comparison of the paths of the amœbas in the two cases.

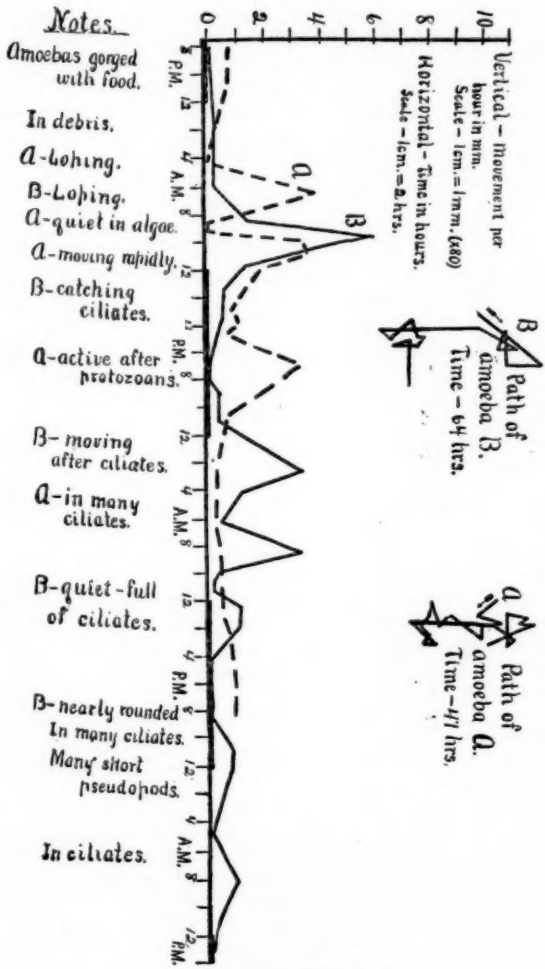

FIG. 5.

A similar investigation made in the Biological Laboratory of Clark University on *Vorticella* seemed to show that this animal worked continuously, without any periods of rest. From this, others (not the investigators) have concluded that proto-

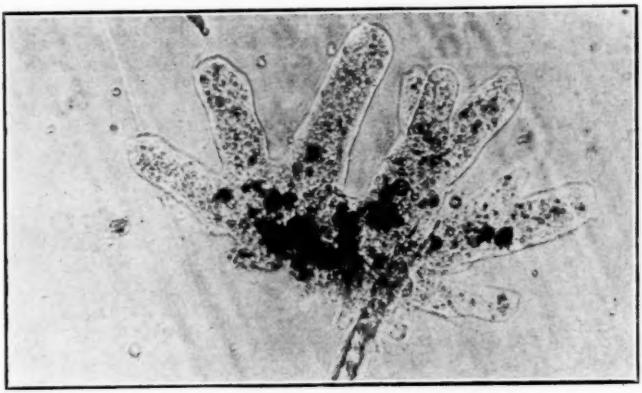

PLATE I. An amœba feeding on algæ.

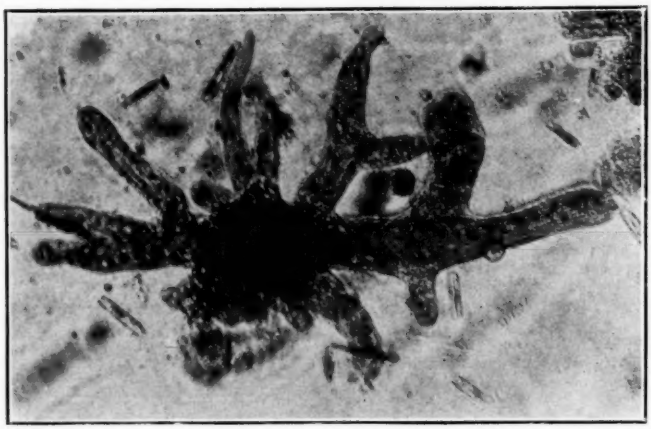

PLATE II. An amœba feeding on protozoa.

zoans never rest and that the rhythm of work and rest was only gradually evolved with the more complex forms of life. It seems, however, that the rhythm is here well developed in this lowest form of animal life, Activity, feeding, rest; activity, feeding, rest, is the story of the above curve. Activity, or the performing of work, requires energy which the protoplasm must supply. The period of rest appears to be simply the result of organic satisfaction, or a period of recuperation. It suggests the lowest form of sleep; for this tendency to rest, to sleep, as a food reaction is illustrated by the higher animals. In this respect this lowest form of life does not differ essentially from the higher forms.

The reactions of the amœba to, and its search for, food also brought out many important facts in its life history.

In the absence of food the amœba often moved by "lopes", that is, by lengthening and shortening its body as a whole without extra pseudopods, and moving rapidly forward.

Amœbas feeding habitually on algæ assumed a palmate form, moving forward with many pseudopods, similar to the form pictured in Plate I.

An amœba feeding on ciliates responds to a touch by a ciliate by sending out pseudopods at the point touched and following up the ciliate. The pseudopods are sent out on both sides of the ciliate until the latter is nearly enclosed and then rapidly connected, forming a chamber, in which the ciliate may finally be engulfed. The ciliate may, however, escape, leaving the chamber open. Some observers, seeing the "pursuit" at this stage, have concluded that the amœba formed the chamber before the partial enclosure of the ciliate.

In the presence of a large number of ciliates the amœba moves about but little. It sends out many pseudopods forming pockets, apparently in readiness for them, and often succeeds in catching them with remarkable rapidity. Our observations seem to indicate that this reaction is characteristic only of amœbas that have for several days been feeding on ciliates.

The adjacent photograph (Plate II) shows an amœba catching protozoa. The following series of camera lucida drawings of an amœba moving into a field containing ciliates shows the forms characteristic in a number of captures and also the peculiar pocketed outline and hooked pseudopods which seemed to be characteristic of forms feeding habitually on ciliates. See Fig. 6.

The amœba often follows a paramœcium or a ciliate until it is caught or lost. This "pursuit" may continue for twenty minutes or more as is indicated by the drawings of an actual instance, Fig. 7. The drawings show the touch by the paramœcium, the "pursuit," the partial capture and formation

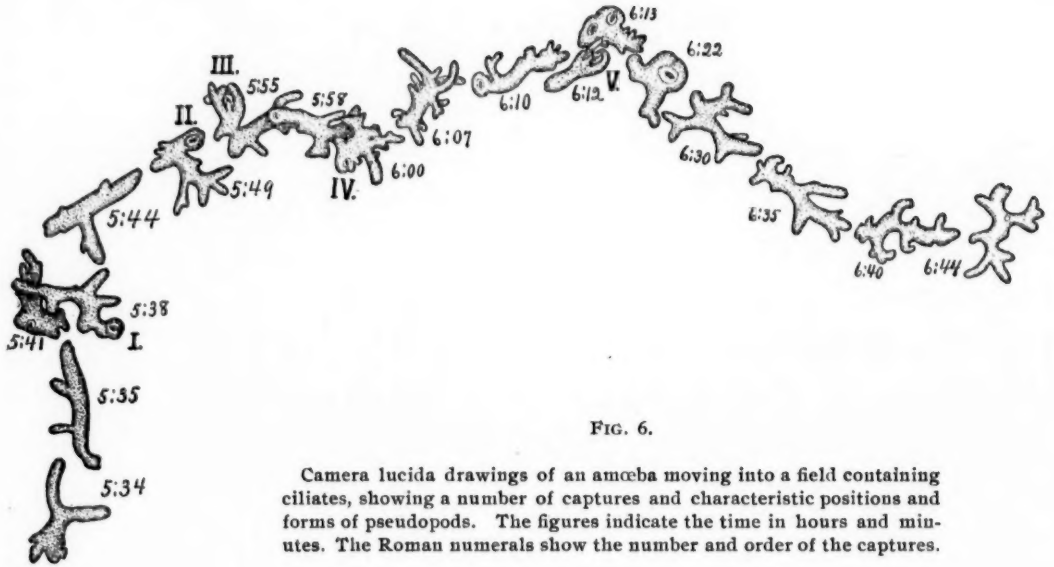

FIG. 6.

Camera lucida drawings of an amœba moving into a field containing ciliates, showing a number of captures and characteristic positions and forms of pseudopods. The figures indicate the time in hours and minutes. The Roman numerals show the number and order of the captures.

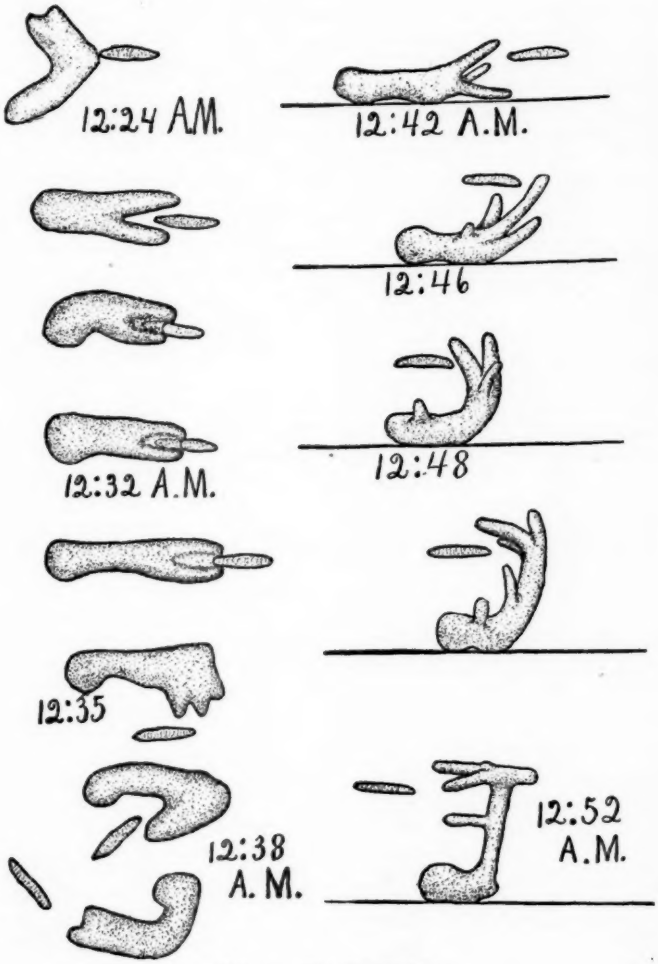

FIG. 7. The "Pursuit".

of the chamber, the escape of the paramœcium, the further "pursuit" at a higher level, and the final escape.

When in "pursuit" in this way the amœba does not generally respond to other stimuli, especially if close upon its prey.

It seems able to detect a paramœcium at some distance, and will continue the "pursuit" some time after the paramœcium has gone from the field. The intensely interesting sight of an amœba after numerous trials gradually sliding its pseudopods around a feeding paramœcium, throwing a cover over it, closing the pseudopods, and gradually squeezing the struggling victim down to a rounded mass can hardly be described without using anthropomorphic terms. It requires a number of adaptations and considerable skill, which our observations seem to indicate are acquired by the "method of trial and error." The capture is seen to be difficult when we compare the reaction times of the two animals. That of the paramœcium is too short to be measured without special chronometric apparatus, while that of the amœba is about one and one-fourth seconds.

The stages and adaptations of "pursuit" are well shown in the photographs by Dr. Dellinger, Plate III. They show the first stage of "pursuit," the gradual enclosure, the formation of the chamber, the tension or squeezing effect, the enclosure, and finally an amœba containing a recently captured paramœcium and the partially digested remains of four or five others.

This slow reaction time of the amœba must be considered when describing its choice of food. It may be seen partially to enclose dead cells or ciliates and then withdraw, for the reaction-choice apparently cannot take place until some time after contact.

The amœba shows distinct food preferences: with diatoms and unicellular algæ, it takes algæ, but when feeding on algæ it will leave them to "pursue" ciliates. In the presence of large paramœcia, some amœbas leave algæ and ciliates to catch these larger forms. Amœba eats nothing dead. This was observed in the case of dead diatoms and algæ cells, of paramœcia dead from natural causes, and of paramœcia which had been artificially killed. Amœbas apparently do not eat their own species, but were seen to eat amœbas of other species.

When the food is changed as a whole, some observations seem to indicate that many amœbas required several days to make the adjustment, especially if this adjustment means new adaptations and movements, as in passing from feeding on algæ to feeding on paramœcia. But all are not alike; some amœbas seemed able easily to adapt themselves, while others were unsuccessful. The advance in complexity of the one stage over the other is very great.

An amœba suddenly placed in the midst of a large number of paramœcia, which bump it and knock it about, usually makes no response to the separate stimuli, but seems "confused." Later, some amœbas in these circumstances, put out pseudopods and may "pursue" a single paramœcium without

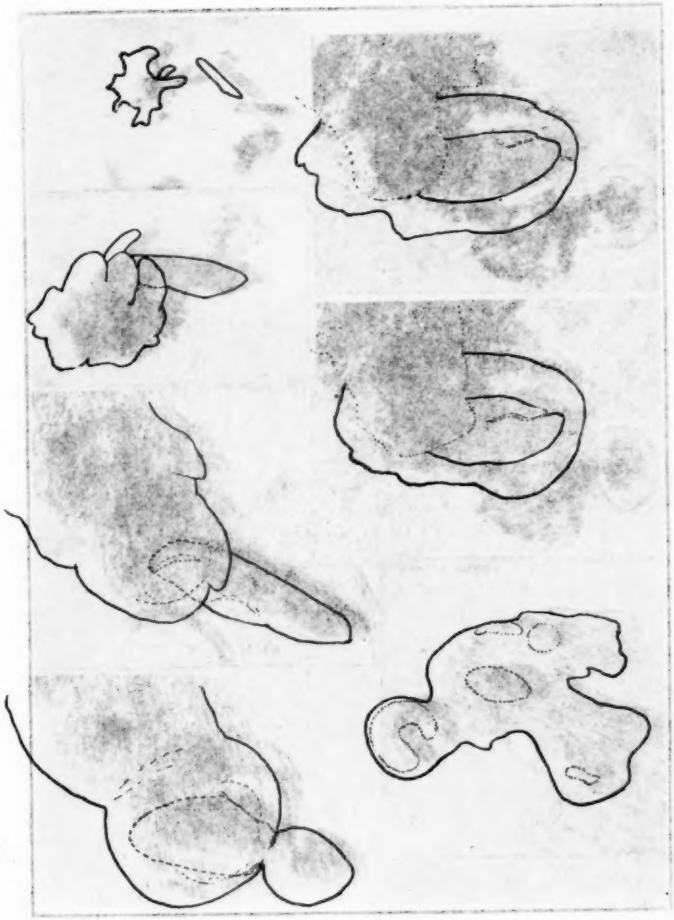

PLATE III.

It seems able to detect a paramœcium at some distance, and will continue the "pursuit" some time after the paramœcium has gone from the field. The intensely interesting sight of an amœba after numerous trials gradually sliding its pseudopods around a feeding paramœcium, throwing a cover over it, closing the pseudopods, and gradually squeezing the struggling victim down to a rounded mass can hardly be described without using anthropomorphic terms. It requires a number of adaptations and considerable skill, which our observations seem to indicate are acquired by the "method of trial and error." The capture is seen to be a difficult when we compare the reaction time of the [illegible]. That of the paramœcium is too short to be measured without special chronometric apparatus, while that of the amœba is about one and one-fourth seconds.

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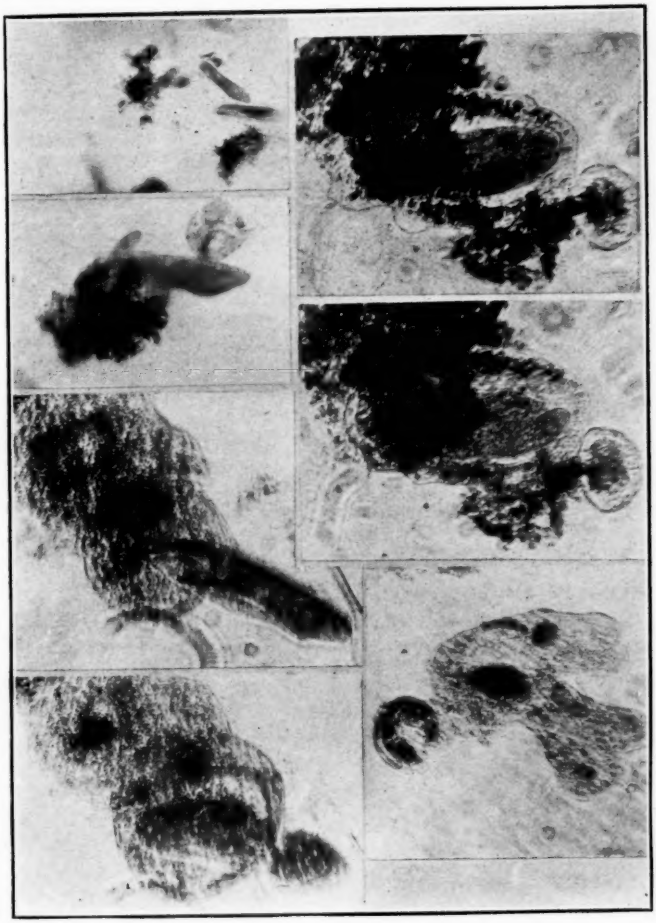

PLATE III.

much regard to touches from the others; while some appear never to get their equilibrium, but move off or take the spherical form.

A number of minor observations should be noted. The action of the contractile vacuole was carefully observed. It was found that the rate of its pulsation varies greatly, but was slowest in nearly rounded and sluggish forms, and more rapid in actively moving forms, that it empties through the ectosarc with a distinct mouth, that some fluid is discharged, that the vacuole usually, if not always, reappears at the same spot. The evacuation of particles was also frequently seen taking place from a food vacuole, the particles being expelled by contraction of the vacuole.

Although amœba were often found in contact, no trace of conjugation was observed. On the other hand, they were frequently observed to avoid each other.

From the facts observed it would seem that

1. The *amœba proteus* in common with higher animals has distinct periods of work and rest, depending for degree and duration upon the nature and abundance of food upon which the animal is habitually feeding.

2. That the *amœba proteus* has food preferences and in general the power of adapting itself to changes in food conditions. This power of adaptation and of choice is perhaps the result of a learning process based upon the "method of trial and error."

3. That the *amœba proteus* is capable of a sort of "pursuit" with the various adaptations which this involves.

The study seems to show that amœba can no longer be considered as a bit of but slightly differentiated protoplasm, but must take its place in the true animal series with the rudiments at least of true animal behavior.

Literature

Recent bibliographies on the reactions and behavior of the Protozoa are so complete and so readily accessible that no attempt is made to repeat them in this brief communication. Instead the reader is respectfully referred to:

Jennings, H. S., '04. Contributions to the Study of the Behavior of Lower Organisms. pp. 253-256. Carnegie Institution, Washington.

—— ——., '04. Physical Imitations of the Activities of Amœba. Am. Naturalist, Vol. 38, pp. 625-642.

Dellinger, Oris P., '06. Locomotion of Amœba and Allied Forms Jour. Exp. Zoöl., III, pp. 337-358.

Hodge and Aikins, '95. The daily life of a Protozoan. *Amer. Jour. of Psychology*, VI, pp. 524-533 (specially referred to because the present paper forms the second number in the series of daily life studies of which that of Hodge and Aikins is the first).

Mengarini, Dr. Marguerite F. Sur la conjugason des amibes. Archiv. Italliennes be Biologie, Vol. XXXIX, 1903, pp. 395-396.

MINOR COMMUNICATIONS

MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF VASSAR COLLEGE

V. THE EFFECT OF IMPERCEPTIBLE LINES ON THE JUDGMENT OF DISTANCE

By HELEN M. MANRO and M. F. WASHBURN

Experiments by Titchener and Pyle,[1] reported to a recent meeting of the American Philosophical Society showed, in opposition to those of Dunlap,[2] that imperceptible shadows so placed as to supply the end lines of the Müller-Lyer illusion did not affect the apparent length of the lines at the end of which they were situated. Below is stated the result of some experiments by a somewhat different method, bearing on the same point. They were suggested by the experiments on "subconscious" perception described in Sidis's Psychology of Suggestion, 167 ff.

The apparatus consisted of two cards, on each of which a horizontal line was drawn in ink. The lines were both 15 cm. long. At the ends of the one, two faint lines, 6 cm. long, extending outward at an angle, were drawn in lead-pencil; at the ends of the other, similar lines extending inward. That is, these lines were in the position of the end-lines in the Müller-Lyer illusion. The cards were then held together, the one above and a little to one side of the other, at such a distance from the observer that the pencil lines were just not visible. The observer was asked to judge which of the lines was the longer. According to Sidis, a letter or figure too far away to be read may be correctly guessed with the aid of subconscious powers of discrimination, and we wished to see whether in a large number of experiments under these conditions the line with the imperceptible out-going lines would be judged longer a greater number of times than the other. The results may be stated in a sentence. The tests were made on ten fairly practiced observers, no fewer than a hundred on each observer. The total number of experiments was 1,370, and in 700 of these the judgment was in accord with the Müller-Lyer illusion. In the case of only two of the observers did the proportion of judgments showing the illusion rise above one-half. In one of these cases, the total number of experiments was 210, and the number showing the illusion was 136. In the other, the total number was 200, and the number showing the illusion was 132. It seems improbable that the lines at the ends had any influence upon the judgments, except possibly in these two cases. Our results are thus in accord with those of Titchener and Pyle.

[1] This *Journal*, xviii, 388; *Proc. Amer. Philos. Soc.*, xlvi, 1907, 94.
[2] *Psych. Rev.*, vii, 435.

VI. The Motor Memory of the Left Hand

By Lucy Rowe and M. F. Washburn

The object of these experiments was to compare the ability to reproduce 'nonsense figures', by means of the left hand, with that shown by the right hand in similar tests. The method used was that employed by Binet to test motor memory, which may be found described on p. 397 of Titchener's Instructor's Manual, Qualitative. The observer's hand was guided by the experimenter along a nonsense figure of six lines, the eyes being closed. The figure was then reproduced from memory. In the course of the whole series of experiments, the same figures were used twice, once in testing the right hand and once in testing the left hand, but with a sufficient interval between, during which other figures were used, to prevent memory of the preceding test. The results were evaluated as follows. A line which was reproduced in the direction which it had in the copy was counted correct. Lines that were reversed, that is, directed to the left when they should have been to the right, were recorded under a separate heading, as were lines that were upside down. When the general direction, right, left, up or down, of a line was correct, but the angle made with the preceding line was too large or too small, the record was made under the head of "Error in angle". The results appear in the following table:

	Right Hand.				Left Hand.			
Obs.	Correct.	Error in angle.	Rev.	U. d.	Correct.	Error in angle.	Rev.	U. d.
WO.	535	119	27	15	551	145	30	10
S.	322	14	21	6	349	15	47	4
H.	282	94	27	28	237	76	54	19
ST.	480	51	43		487		47	45
R.	173	14	36	8	181	19	17	12
L.	254	48	25	16	271	36	36	14
H.	414	106	31	10	465	77	41	19
P.	239	43	46	15	243	25	57	20

We had rather expected that the right hand would show superiority over the left hand in these tests. It will be seen from the table that in every case but that of observer H. the left hand gave a larger number of correctly reproduced lines. The introspection of our observers suggested a plausible explanation for this fact. We are so unaccustomed to performing accurate movements with the left hand that attention to its experiences in the giving of the copy is more strained and apparently more effective. The movements of the right hand, on the contrary, are more nearly automatic, and being less attended to are less accurately reproduced.

It might be expected also that the left hand would show a stronger tendency to reverse movements in reproducing them than the right hand. The figures show that this was the case with every one except observer R., though the difference between the hands was not very marked.

VII. A Study in Guessing

By Marie Stroh, A. Margaret Shaw, and M. F. Washburn

The experiments to be described were suggested by those of Sidis,

described on pp. 168-171 of "The Psychology of Suggestion." Cards bearing printed letters or numbers were in Sidis's tests held at such a distance from the observer that they could not be read, and the observer was asked to guess the letter or number on the card shown. Sidis found that in a certain percentage of cases too large to be due to chance the guesses were correct, and argues that a secondary self, endowed with better powers of vision than the primary self, influenced the guessing.

Our own experiments fall into three series. In the first of these, a procedure like that of Sidis was followed. The cards used bore each of them one of the first ten letters of the alphabet, and they were held at such a distance that the observers could barely detect the letter as a faint spot on the card. The observer was told that the letter on the card was one of the letters from A to J. In a large number of experiments, then, the probability would be that one-tenth of the guesses at the letters would be correct, if the guessing was not subject to any influence.

In the second series, the conditions were rendered more difficult by enclosing the letters in rectangles. It was thus made almost impossible to be guided in guessing by the general bulk of a letter,—as, for instance, B might in the first series be distinguished from I.

In the third series, the letters were whispered instead of being shown on cards. It was found necessary in this series to rule out every experiment where the observer heard the slightest sound from the whispering. If anything at all were heard, it often caused the letter to be recognized, especially such letters as C, G, H and J. The experimenter would therefore give the observer a 'Ready' signal, and then whisper the letter so softly that no sound whatever could be heard at the distance at which the observer sat.

The following tables show the results of these series:

Series I. Printed letters without enclosing rectangles.

Observer.	No. of Experiments.	Per cent. of correct guesses.
Str.	100	38
S.	100	32
M.	100	38
R.	200	33
Si.	126	48
W.	310	24
H.	200	51
B.	50	16
L.	50	22
P.	50	16
Bo.	100	55
E.	100	74
Li.	330	46

Series II. Printed letters with enclosing rectangles.

Observer.	No. of Experiments.	Per cent. of correct guesses.
Str.	100	37
S.	100	21
Si.	100	24
W.	240	63
P.	50	18
L.	50	34
B.	50	8
E.	200	67

Series III. Whispered letters.

Observer.	No. of Experiments.	Per cent. of correct guesses.
Str.	600	31
S.	400	19
M.	100	12
H.	400	16
L.	250	10
W.	200	39
Bo.	100	13
E.	106	16
Si.	200	24
P.	200	23

From these tables it appears that only one observer, B. in Series II, ever fell below 10 per cent. of correct guesses, the proportion required by mere chance, and that in this case the number of experiments was so small that the law of probability would hardly apply. In Series I, some of the observers, for instance E., Bo., H., and Si., obtained so high a percentage of right guesses as to suggest that they must have been almost able to read the letters, although they declared in good faith that they could not. The possibility of reading in the ordinary sense was much less in the second series, yet two of the observers, E. and W., guessed right in more than half of the cases. In Series III, where the letters were whispered, since every case in which the observer heard the slightest sound of the whisper was ruled out, the conditions should have made ordinary perception impossible. It is noteworthy that although no observer fell below 10 per cent. of right guesses in this series, L., M., and Bo. had but little above that amount. Yet Str. and W., with 31 and 39 per cent. respectively, show that their guessing must have been somehow influenced quite decidedly in the right direction, and the others also give evidence of such influence, though in a less marked degree.

Our results, then, confirm, on the whole, those of Sidis and show that with certain observers at least judgments may be influenced in the direction of correctness when the observer is unconscious that any such influence is present. Whether this effect is due to a secondary self with superior senses, as Sidis believes, or to a physiological result of the stimulus, too slight to affect consciousness on its own account, as it were, is a question to which our experiments can furnish no answer.

VIII. A Study of Errors in the Perception of Movement on the Skin

By Ruth Hoag, Julia A. Lindemann, and M. F. Washburn

The object of this study was to test the generally accepted statement that movement and rest can be correctly discriminated when the direction of the movement is not accurately perceived, a fact which Külpe explains by the law that "general or abstract names are more easily reproduced than concrete." Movements of very slight extent on the part of a tactual stimulus were employed. The observers sat with the left arm extended on a table, and with their eyes closed. An ink-dot was made on the volar side of the wrist, about 5 cm. above the hand. Four other dots were placed at distances of one mm. from the first, one each in the central, peripheral, radial, and ulnar direc-

tions. The rubber point of an ordinary æsthesiometer was placed upon the skin at the centre dot, and either moved in one of the four directions to another dot, or held upon the centre dot for a period as nearly as possible equal to that occupied in a movement, that is, about one second. The observer judged whether the point had remained at rest, or had moved, and the direction of its motion if it was thought to have moved.

Twelve observers, all women, served in the experiments, and 7,100 experiments, in all, were made, no fewer than 500 on any one observer. It seemed at the conclusion of the study that the distribution of the errors made in so large a number of experiments was not without interest. A table showing it is therefore presented.

Actual Movement of Stimulus	Judgments					Total Errors
	Central	Peripheral	Ulnar	Radial	Rest	
Central	1094	45	58	106	117	326
Peripheral	51	1050	80	83	156	370
Ulnar	123	90	1020	43	144	400
Radial	119	84	15	1083	119	337
Rest	63	52	54	46	1205	215
Total Errors	356	271	207	278	536	

The results that appear from this table may be summarized as follows:

1. A resting stimulus is judged correctly as resting oftener than any direction of movement is correctly perceived.

2. On the other hand, when a moving stimulus is incorrectly perceived, it is more likely to be judged as at rest than as moving in a direction other than its real direction.

3. Next to a resting stimulus, the order of accuracy in the perception of the stimuli is: central, radial, peripheral, ulnar. But the superiority of the central direction is crossed by result 4 in the same way that result 1 is by result 2.

4. When the direction of a moving stimulus is incorrectly perceived, it is more likely to be called 'central' than any other direction. This is in entire accord with the results of Hall and Donaldson, who say, "We are more likely when in doubt to judge motion on the surface of the limbs to be up rather than down the axis."[1] They suggest that this is due to the fact that movements up the skin would ordinarily be produced only by some living thing, while movements downward would be common experiences through gravitation.

The possibility then suggests itself that instead of rest's being better perceived than the direction of motion, and movement in the central direction better than movement in any other direction, there may be simply a general tendency, when in doubt, to say 'Resting' or 'Moving centrally.' This would account alike for the facts that there were more correct judgments under these two heads than under the others, and that more wrongly perceived stimuli were assigned to these two classes.

Examination of the individual records of the different observers throws some light upon this point. The following facts appear from such an examination:

(*a*) Only six of the twelve observers judged the resting stimulus best of all.

(*b*) Of these, five were more apt to call a misjudged stimulus 'resting' than anything else. Two other observers showed the same tendency.

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[1] *Mind*, O. S., X, 559.

(*c*) Five observers only judged the central direction either best of all or next best after the resting stimulus.

(*d*) In four out of these five cases, the number of wrong judgments that involved calling the direction of movement 'central' was either greatest of all, or second only to the number where the stimulus was called 'at rest.'

It looks, then, as if there were a tendency on the part of some of our subjects to make the judgments 'resting' or 'centrally moved' when uncertain, which may account for the apparent superiority of judgments under these two categories.

IX. A Suggestion towards a Study of the Perception of Sound Movement

By Joyce Hicks and M. F. Washburn

The method used in the experiments to be described was as follows. The observer sat with eyes closed. The experimenter stood either behind her, to her right, to her left, or in front of her, and held a König tuning fork, mounted on its sounding box, at a distance of about 50 dm. from the observer's head and on a level with her ears. Chalk marks were made on the floor 30 dm. to the right and left of the point directly over which the fork was held. The fork used was a C^2 of 1,024 vibrations. The fork was struck with a felt hammer by E and moved 30 dm. to the right, left, up, or down. The extent of the movement to the right or left was guided by the marks on the floor; the movements up or down had to have their extent governed merely by E's attempt to make it as nearly as possible equal to that of the others. The duration of the movements was governed by a rhythmic count 'one-two' mentally made by E. An equal number of experiments was made where the movement was in each of the four directions, and also when the fork was held perfectly still and allowed to sound the same length of time as that occupied by a movement. The same number of experiments, in the four directions and with the fork at rest, was made at four different positions, in front of the observer, to her right, to her left, and behind her. Seven persons served as observers, and 164 experiments were made in each of the four positions, making 656 in all.

Tables showing the results are subjoined.

Position: Front

Direction of Movement	Judgment: Up	Down	Right	Left	Rest
Up	39	27	30	31	37
Down	44	23	33	24	38
Right	25	9	101	13	16
Left	36	23	10	79	16
Rest	29	19	22	5	89

Total correct judgments in this position: 331.

Position: Back

Up	89	30	14	4	27
Down	27	65	22	15	34
Right	21	8	115	8	12
Left	23	11	5	96	18
Rest	28	19	5	10	102

Total correct judgments in this position: 467.

Position: Left

Direction of Movement	Judgment				
	Up	Down	Right	Left	Rest
Up	68	8	22	38	28
Down	25	49	23	50	15
Right	28	17	60	24	35
Left	32	10	34	44	34
Rest	16	22	14	14	98

Total correct judgments in this position: 319.

Position: Right

Up	72	14	38	17	23
Down	36	26	45	28	28
Right	41	27	55	21	21
Left	42	20	17	58	27
Rest	23	10	14	12	104

Total correct judgments in this position: 315.

It is unnecessary to point out how rough the method employed in these tests was. There was no accurate control either of the extent of the movement, or of its rate, or of the intensity of the tone. Yet all three of these defects represent variable errors, and in so large a number of experiments they would approach elimination. In any case the study may be useful in suggesting a problem to some one who has more accurate apparatus at his command. A few of its results are sufficiently decided, both in the tables given above and in the figures from the individual observers, to claim some validity. They are as follows:

1. The direction of sound movements is better perceived when the moving tone comes from behind the observer than when it is in any other position. There were 467 correct judgments in this position, whereas 331 was the highest number in any other position. This is interesting because of the tendency noted in experiments on the localization of a resting sound to throw the sound back, a tendency which Gamble explains as due to "serviceable reflex movements in response to noise".

2. When the tone was at rest, the fact was more accurately perceived than was movement in any direction. The total number of correct judgments of the resting tone was 393; the next highest number was 331 for movement to the right. This superiority of the judgments of rest does not seem to be counterbalanced here, as in the experiments on tactile perception of movement, by any tendency, either general or on the part of individuals, to say "no movement" whenever in doubt.

3. Movement downward was on the whole most poorly perceived, the number of correct judgments being 163, and the next higher 268 for movement up.

This may be due to the same cause that renders sounds less easily localizable in the median plane.

THE IMAGINATION OF ADOLESCENTS

By WALTER LIBBY

Under this title I wish to record a particular investigation carried on during the last two years. No attempt is made to treat the subject of adolescent imagination comprehensively or even to show all the pedagogical inferences to be drawn from this special study. In fact the scope of what I have to say is still further limited, as the investigation concerned itself merely with one aspect of the general topic, namely, the relation of the imagination of school children to their feelings.

In the first place there was presented to a fourth year class of Illinois High School pupils a somewhat sentimental picture on which they were asked to write a composition. In the foreground of the picture a young lady stands at an old-fashioned gate weeping, and in the background a horseman in white suit and cocked hat is riding away. The class to whom this was first presented consisted of forty-one,—seventeen boys and twenty-four girls. The compositions written by them showed that the picture appealed strongly to their stage of development. All the students wrote fully and with apparent spontaneity. The teacher, who wrote a few comments on the margins, was inclined to prune away epithets and to check the exuberance of the style. The "fine writing" of which the pupils were accused by their preceptress seemed to me to spring from the exaggerated ardor of their feelings as gauged by maturer standards. If these so-called faults in writing are merely matters of literary style, then style must be considered very vital and personal, and to really modify it would involve a reformation of the pupil's nature.

In order to establish a basis of comparison this same picture was presented to pupils in an Illinois grade school, namely, to twenty-three of fourteen years of age and over, to fifty-one of thirteen years, to thirty of twelve years, twenty-three of eleven and seventeen of ten. Needless to say there was a very marked difference in the compositions from the grades and those from the fourth year High School class. This difference can be briefly described by saying that the compositions from the grades were largely objective, while those from the High School class were decidedly subjective. Also noteworthy is the fact that the line of cleavage occurs after the fourteenth year. I was led to make a somewhat closer study of the returns from the twenty-three grade pupils of fourteen years and over as compared with the returns from the fourth year High School pupils. I found that the general and rather vague distinction indicated by the terms subjective and objective admits of more definite statement. Of the twenty-three grade pupils twenty,—nine out of nine girls and eleven out of fourteen boys,—mentioned "the picture" as such, while not a single such reference occurs in the forty-one High School productions. All the latter entered at once sympathetically into the situation portrayed. The picture aroused their emotions and *ipso facto* stimulated the imagination.

Closely related to the objectivity of the work in the grades is the inclination to give a number of loosely connected details. In the High School compositions the observations are unified by the underlying emotion. This might be stated from the point of view of the teacher

of rhetoric. The more mature productions are marked by greater unity, more careful explicit reference, and a more complex sentence structure. To deny that the language teacher is to be credited with a considerable share in this improvement would be to take a cynical attitude towards the profession, but to deny on the other hand that the natural evolution of the adolescent powers is a large factor in this change would be to ascribe to language teaching a more artificial character than it deserves. The teacher of composition can exhort the pupils to select in writing a certain point of view, but in imaginative writing the magnet that draws to a centre the details of the work of art is the emotion of the writer. To illustrate from our returns, in eight of the forty-one High School compositions the mood, the emotional tone of the essays, was struck by the words "Never to return," but no such phraseology is found in the work from the grades. It may be worth noting that seven out of the eight compositions in which this melancholy refrain occurs were written by adolescent girls. Sixteen of the High School boys took it for granted that the man on the black charger was the young lady's lover riding away; one took him for a young husband. Of the twenty-four High School girls eighteen thought he was a lover, one a messenger, one a father, and four a brother. Of the fourteen grade boys five took the horseman for a husband, one for a lover, one a son, one a son or brother, the remaining six failing to see him or to specify. Of the nine grade girls four thought him a husband and one a lover, the other four neglected the question.

Fully one-third of the older students imagined the hero and heroine to have been friends in childhood, while to only one of the grade pupils did this idea occur. In this matter we might think that the adolescents had been influenced by their reading of novels, especially as childhood friendship is mentioned by the boys almost as frequently as by the girls. Certainly imitation of the fiction read by these students would strike the most careless reader of these essays, but we must expect that the adolescent mind adopts for its own that which really appeals to its nature.

It is, of course, obvious that their studies and more serious reading must influence and give balance to the pupils' imaginative constructions. Of the High School boys ten make Germany the scene of the plot and one, France. Of the High School girls eight locate the incident in Germany, five in France, four in America, two in Austria, and one in England. Of the grade boys one mentions Germany, two America, besides one who calls the cavalier a cow-boy. The grade girls disregard the geographical question. A large percentage of the High School pupils mention definite times like the war of 1870, of 1696, and the war of the Austrian Succession. Among the grade pupils two mention the War of the Revolution, one the Colonial Period, one "once upon a time" and one "olden times." That the incident portrayed in the picture occurs in war time is taken for granted more frequently in the High School than in the grades, and more frequently by the boys than by the girls.

Although, as already stated, the compositions in the grades are markedly detailed, a single detail, the autumn leaves lying on the ground, is more frequently mentioned by the older pupils. The High School girls especially make a point of the dead leaves. By them, however, the leaves are not considered merely as a detached detail, but are given unity, by their emotional suggestiveness, with the whole story. They are symbolic of the melancholy of a touching farewell. The High School pupils, and again especially the girls, are bolder in the use of ornate and unusual epithets. The grade pupils seldom venture

beyond such descriptive terms as "swampy" and "fine," although in one case "sad-looking" was used. The epithets used by the High School girls indicate that they are more eye-minded and more ear-minded, less motor-minded than the boys. One feels in reading these compositions how great a part is played in emotional scenes by faintly heard sounds, impressions of temperature, and of slight pressures, such, for example, as are produced by a passing breeze. Among the adolescents again greater imaginative sympathy is indicated by the use of direct discourse, the first person and proper names. I was disappointed by the absence of burlesque in the High School compositions. Only one boy gave the comic muse rein, suggesting that the moral of the story was "that soldiers, book-agents and travelling men generally were not to be trusted."

One of the most characteristic things about the High School returns is the rhythm, the musical swing of the sentences and paragraphs. The imagination seems under the sway of a musical mood. The likeness of the compositions to popular fiction is in this respect remarkable. One might describe this rhythm as a sentimental languorousness, similar to the cadence of a Strauss waltz. This characteristic could, I think, be expressed less vaguely in the terms of rhetoric.

I shall not go into details in reference to the latter part of my investigation. After establishing the distinction between the imaginative work of students of eighteen years of age and those of fourteen, I submitted this same picture to the four classes of an Illinois academy in order to show stages in the development of the imagination during the High School age. Later a picture of a Roman Chariot Race was presented to the four forms of an Ontario Collegiate Institute. It appeared from both of these sets of returns that the great emotional and imaginative change in adolescents came after the age of sixteen. The chariot race met with less comprehension and appreciation from boys of fourteen and fifteen than I had expected. Occasionally all enthusiasm for the race was smothered by a schoolmasterly, expository spirit.

A popular picture with an ambiguous title, *In Full Cry*, was given as a subject of composition in the four forms of a second Ontario Collegiate Institute, and also in the four forms of an Ontario Normal School, where the students average twenty-one years, in order to secure a basis of comparison between High School students and those of maturer age. Finally, a picture called *A Serious Affair* was presented to the four forms of a third Ontario Collegiate Institute and to three forms of an Ontario High School.

The whole investigation confirms the views of various experts as to the close interrelation of the imagination and the feelings. What differentiates prosaic thinking from imagination is the presence of the feeling factor. All the emotions serve as stimuli to the imagination. A genetic view of the emotions has shown in recent years their importance in the maintenance of individual and racial life. If the connection of the imagination with the feelings be firmly established, the vital value of the functioning of the imagination can be inferred. It is no semi-superfluous power that may be exercised or held in abeyance at will, but an aspect of consciousness that may be discerned in every mental process of capital import. I am led, therefore, to dissent in part from the conclusion reached in certain recent investigations similar to mine, which, unduly emphasizing the study of the image, and neglecting the functional aspect of the imagination, claim that the imagination is poorer in the pupils in the High School than in those of the grades. Adolescence is the birth of a richer emotional life, which is dependent in turn upon a wider range of associations,

and upon physiological changes, including the rapid growth of the heart and the development of the tangential fibres in the brain. At the same time adolescence is the dawn of the brightest and most vivid imaginative period. To claim that poor High School teaching has actually reversed the order of nature seems to me to claim too much for defective pedagogy. That our High School teaching is wanting as judged from the standpoint of the psychology of the imagination I feel forced to admit. Much of the work is trivial, desiccated and barren. The imagination shown in our secondary schools is meagre in comparison with what it might be. But High School students have not lost the imaginative function. It would be truer to say that we instructors have lost the control of this vital activity and that cheap fiction is usurping the domain of the educator. When we consider the importance of the imagination for the moral life, that in our imagination we rehearse our virtues and our vices, we must envy the novelists, actors, elocutionists, and artists who sway the imagination and its underlying emotions.

MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CLARK UNIVERSITY

XXII. Children's Capacity for Abstract Thought as shown by their use of Language in the Definition of Abstract Terms

By Louise Ellison

The close dependence of thought in all its higher forms upon language has been universally recognized. To think in any but the most concrete way means almost without exception to think in words. Without abstract terms generalization can reach but a low level; and at its higher levels the word (or symbol standing for it) is the sole means of holding and using the general idea.[1]

But this is not all; in not a few cases the learning of the abstract term is an important step towards becoming acquainted with the abstract idea for which it stands. The word assists in sharpening attention and gives notice that an idea corresponding to it exists and may be found. How much of human capacity in dealing with abstractions depends on the fact that children are born into a speaking environment would be hard to estimate, but the influence is certainly not small.

Facility in the use of language is in some degree, therefore, an index, though of course not the only one, of mental development. The age at which children learn to speak and the number of words which they can understand and use at various ages have long been a matter of interest both to parents and to students of the early stages of child life, and several laboratory tests turning exclusively on knowledge of words or skill in handling them have been proposed for determining mental condition at different ages.

A step beyond the ordinary comprehension and correct use of abstract terms is required, however, for the exact definition of them. No one has reached the highest level of skill in abstract thought until he is able to state the precise scope and limitations of the terms that he uses. The method and the success of attempted definitions may thus serve as still another measure of attainment in the power in question.[2]

In view of all this, a study of the ability of children of different ages in the defining of abstract terms might be expected to give useful information with reference to their advancement in the power of abstract thought and no doubt would do so, if carried out under favorable circumstances and with due regard to the correlation of

[1] Ribot: Evolution of General Ideas.

[2] Definition, from a psychological point of view, is an effort to call up in the mind of another an adequate conception of an idea in the mind of the speaker. Many means may be employed for thus "conveying the idea." The child or the practical man often does so by giving a sample—by citing an instance or giving an example or even by pointing out, or showing, what is meant. The logician defines by genus and difference. Between these two extremes there is a considerable range of procedure, some forms of which appear in the data to be considered.

power of this sort with that in other directions. The present study goes but a short step in that direction, however, for the material, while collected under the supervision of a university professor in the schools of a western city and kindly placed at the disposal of the writer by him, is adequate only for a study of the relation of age and sex to defining ability in a mixed group of children, and furnishes no information upon a number of points upon which information would be desirable. The relations which seem to be clearly established can be stated briefly.

The material consisted of the definitions for twenty-seven more or less abstract words in common use written by boys and girls of from eight to fifteen years of age. These were gathered by the teachers under the guidance of the following circular of instructions.

"To the Teachers:

(1) Please ask the children in your room to write on paper the meaning of each of these words.

(2) Have each child write his or her *first* name and age at the top of each sheet of paper used.

(3) Write the words on the blackboard, but only so many each day as may surely be defined during that period.

(4) Pronounce a word as often as a child wishes, and in the lower grades each word should be spoken as well as written.

(5) It is of the greatest importance that you should *not* give them any information that would suggest a definition, as this would make their definitions useless. Do not tell them not to use in their definitions the word that they are defining. It is the *child's* definition that is wanted.

(6) After the children have written the meaning of all the words, please tie their papers in a bundle, write the grade on the outside and hand the package to your principal.

Words to be defined:

1. hunger
2. weight
3. slowness
4. shape
5. color
6. laziness
7. courage
8. strength
9. goodness
10. love
11. length
12. happiness
13. size
14. use
15. thankfulness
16. truth
17. life
18. hardness
19. health
20. anger
21. neatness
22. pleasure
23. man
24. play
25. house
26. boy
27. home

The total number of children who answered was 472, of whom 253 were girls and 219 boys. The number of papers for each age and sex was as follows: Girls, 8-year-olds 9, 9-year-olds 44, 10-year-olds 52, 11-year-olds 51, 12-year-olds 47, 13-year-olds 28, 14-year-olds 13, 15-year-olds 9. Boys, 8-year-olds 11, 9-year-olds 39, 10-year-olds 46, 11-year-olds 35, 12-year-olds 40, 13-year-olds 27, 14-year-olds 17, 15-year-olds 4. The total number of definitions considered was about 12,000, some of the children having failed to define some of the words.

All of the definitions which were legible were used in the classification. The basis of classification was for most of the words chiefly the way in which the thought was expressed (*i. e.*, the grammatical or rhetorical form of the definition), but as a rule form and content

ran parallel and content was so far regarded in all as to lead to the placing in a class by themselves of all those definitions that seemed to the classifiers as reasonably adequate. In the case of four words, however, *man*, *boy*, *house*, and *home*, the definitions were grouped according to content chiefly, but even here content and form ran closely enough together to allow these words to be taken into account in the general comparison. In the few cases where more than one definition was given for a single word the first one only was counted.

The classification of the definitions proved to be anything but an easy task; but was, nevertheless, carried through with care. To insure as great exactness as possible the writer first worked over the entire material alone and then a second time in conjunction with Dr. Sanford. The classes finally made when form of expression was the chief criterion are given below. Those made for the words classified according to content will be considered by themselves later.

(1) Definitions by use in a phrase or sentence, as: "Size, My size is very much."

(2) Definitions consisting of the word to be defined followed by "of something," "of anything," as: "Weight is the weight of something." It is difficult to tell whether these really belong to the preceding group or to an independent and early stage of real abstraction.

(3) Definitions involving the mention of a person or thing, as: "Pleasure, somebody that has fun;" "Thankfulness, somebody that is thankful."

(4) Definitions by examples, as: "Color means like red or blue."

(5) Definitions by the use of an adjective, as: "Anger means mad."

(6) Definitions by means of clauses introduced by *when*, *that* or *if*, and having somewhat the nature of examples; as: "Weight means when you are heavy;" "Size means when you are big; when you are fat and chunky;" "Neatness when you are clean." These will be referred to as the when-that-and-if clauses.

(7) Definitions by infinitives, as: "Hunger, to be hungry;" "Thankfulness, to thank somebody."

(8) Definitions by means of synonyms, as: "Happiness means joy;" "Life means existence."

(9) Definitions which, allowing for the child's informal use of language, seemed to the classifiers as on the whole adequate—definitions where the knowledge of the meaning is certain and the thought fairly well expressed. This class will be referred to as that of "Fair definitions." Examples: "Laziness is a habit when you are not ambitious;" "Pleasure the act of enjoying;" "Boy, a young man."

(10) Definitions which resisted classification either because unintelligible or because they could not be brought into any one of the other groups. This class will be known as the "Miscellaneous group." Not all were necessarily poor as definitions; a few might almost have been put in the ninth class, but because of some special peculiarity seemed better classed here.

Besides these ten classes, found more or less frequently for nearly all the words, there were for many words small groups of definitions of forms found rarely or not at all in the case of other words. These will not be further considered.

Though the ten chief classes are moderately distinct as outlined above, there arose in the actual classification a good many cases of doubt and a few in which the decision was felt to be more or less arbitrary. For this reason no importance can be attached to the particular figures found for each class, though the broader relations may still be assumed to hold good, to these alone reference will be made in what follows.

All the words, except *life*, which is *sui generis*, themselves fall into groups within which the proportions of definitions of the various classes are about alike, and of which a single word may be taken as typical.[1] It will be noticed also that these groups, quite apart from the children's treatment of them, belong in a measure to different sorts of abstractions. The type words and their groups are as follows:

PLEASURE: play, use, truth, love.
WEIGHT: size, length, strength.
HEALTH: hunger.
ANGER: courage.
HAPPINESS: neatness, hardness.
THANKFULNESS: laziness, goodness, slowness.
COLOR: shape.
BOY: man.
HOUSE: home.
LIFE.

The definitions, excluding the miscellaneous ones, may themselves be arranged in three, more general groups, which for convenience may be spoken of as (A) Definitions by Sample; (B) Definitions by Abstract phrases, and (C) Definitions by equivalents (including under that head the synonyms and "fair definitions").

A. *Definitions by Sample.*

These include the first five of the classes mentioned on page 255, in all of which the child's effort is to convey the thought indirectly by putting the hearer into a position in which he can grasp it for himself.

1. Definitions by Use of the Word in a Phrase or Clause. In these, so far as the child really tries to give the meaning of the word, he tries to do so by showing how it may be used, and in that way to suggest its meaning. In this procedure he is also very likely copying his seniors; for it is often easier to explain a word to a child by showing him how to use it than in any other way, and often satisfies him quite as well as would a genuine explanation. In the early school years also, much of the child's attention is given to getting command of the mother tongue, which would also incline him towards this sort of definition. Finally, it may be possible that for many of the youngest children the test words were taken in chiefly as auditory impressions and suggested their speech associates without much real conception of their meaning. In any case it is not surprising to find this sort of defining strong with the 8-9-year-olds, and falling rapidly away for the others.

2. Definitions Consisting of the Word to be Defined followed by "of something" or "of anything."

3. Definitions Involving the mention of a Person or Thing.

[It is difficult to tell whether the definitions of these two groups really belong with the illustrative phrases of Class 1, or stand for a stage in which the abstract quality can in a measure be focussed in attention, but cannot yet be wholly separated from the concrete context,—a sort of practical *universalia in re*. In any case the definition operates by reference to a relatively concrete instance. The numbers

[1] With regard to the differences within these groups the following may be worth mentioning: *Truth* has no examples and no fair definitions." *Play* and *love* have no adjective definitions and few synonyms. *Use* and *courage* are in general poorly defined. All the words ending in "ness" are treated by the children in much the same way, but *thankfulness* and the words grouped with it are defined somewhat more frequently in a way to bring out their active aspect. Other variations of the typical words among themselves, as far as they seem of interest, will be noticed later.

in both cases are too small to allow any certain inference as to the correlation with age].

4. Definitions by Examples. This is the typical case of primitive definition uninfluenced by the linguistic tendency of the first three classes.[1] Where the numbers are of some size, as in the case of the boys, there is a marked decline in this sort of definition as age increases.

5. Definitions by the Use of Adjectives. As evidence of power of abstract thought definitions of this sort stand upon about the same level as those of the second, third, and fourth classes. The correct use of an adjective involves a recognition of the existence of the quality indicated though not separated from the substance in which it inheres. Definition by the use of adjectives may thus be a verbal means of pointing out the essential quality in the thing defined. The precise words used will vary of course with the child's power of expression and his desire to avoid using words of the same root as those defined. He may say, "Laziness means lazy," or "Laziness means tired," according to his vocabulary and his notion of what is required in defining, without essentially differing in his mastery of the abstract idea. Definitions of this class like those by use of the word in a phrase or sentence belong on the whole to the younger children and decline noticeably with increasing age.

B. *Definitions by Abstract Phrases*

6. Definitions by When-that-and-if Clauses. This class marks, perhaps, a certain advance upon that of the adjectives, but like the latter shows a characteristic decline with increasing age. The typical forms, such as "Happiness, when you are happy," "Laziness, means that you don't want to come out of the bed," "Love means if you love that girl," all define by citing instances; but citation by a somewhat indefinite phrase indicates, perhaps, a little loosening of the abstract quality from its matrix in the concrete.

7. Definition by the Use of the Infinitive. With the definitions by means of infinitives we seem to pass from the lowest grade of definitions to a middle grade, though even here not a few of the definitions really cite examples. The infinitive is the most abstract form of the verb (except the participle) and usually in the definitions studied carries neither subject nor object. The following may serve as instances in which the infinitive seems to stand for a middle degree of abstraction: "Heaviness, to be heavy;" "Thankfulness, to be thankful;" "Truth, to be true." In the following it seems rather more like an example: "Hardness, to work hard;" "Play, to play games; to play dolls." Taking both sorts of infinitives together the figures show a rise in frequency up to twelve years with a slight (though perhaps accidental) fall for the 13-14-15-year-olds.

C. *Definitions by Equivalents*

8. Synonyms. Definitions by synonyms may seem to testify rather to an increased vocabulary than to an increased ability to handle abstractions, and doubtless it does so, but the choice of synonyms as a means of definition indicates at least a neglect of the more primitive forms and thus a certain advance. The increase of this form with age is noticeable in the case of both boys and girls.

9. Fair Definitions. These are infrequent with any of the children and nearly or quite lacking in those under ten or eleven years of age.

Summing all this up in a single word we may say that such a mas-

[1] Lloyd Morgan: Introduction to Comparative Psychology, 2 ed., p. 229.

tery of common abstract ideas and of language as would make possible reasonably perfect definitions is nearly or quite wanting in children of thirteen and under, though for several years before that time the abstractions have been clearly enough grasped and the vocabulary has been large enough to allow a good deal of definition by synonyms. Still earlier the children seem to hold the idea in a distinctly concrete fashion and to convey it, when required to do so, by means of concrete examples variously expressed, while the youngest children of all in many cases cite examples of the use instead of really giving the meaning of the word, possibly for the reason that at that stage the idea itself cannot be brought clearly before consciousness.

Definitions by Negatives. Definition by negative forms includes such as the following: "Truth means no lie," "Happiness is not sad," "Laziness, somebody that does not want to work." The negatives for each word were compared with the number for every other word with the following general results: *Hunger*, from the very nature of the term had so many negatives (negation being implied even where it was not expressed) that it was classed by itself. Excluding *hunger*, *truth* has more than one-fifth of the total number of negatives for all the words. The form they take is "not to lie," "not false," "no lie." *Laziness* comes next with a little less than one-fifth. Here the negatives are used in such expressions as, "not to work," "don't want to do anything," and the like. Next comes *health* with expressions like, "not sick," and *slowness*, with such as "not fast," "not to go fast." There are none for *weight*, *length*, *size*, *use*, *house*, and only two or three each for the remaining words. There is a general increase of definitions by opposites or by the use of the negative from the younger to the older children. For *love* and *color* where there are only a few negatives to compare there is an exception, but not a marked one, to this statement.

As regards differences between the boys and the girls in ability to define, it seems certain that the girls succeed better than the boys at almost all points, getting rid earlier of the more primitive methods of indicating the idea and taking up earlier the more advanced.

Words Classed according to Content

The words *man*, *boy*, *house*, and *home* were classified according to content and not especially by form, as has already been said, though a number of the forms common in the other group occurred here also. The definitions for *man* have nothing corresponding to "a child" which constitutes a large class for the word *boy*, but the main classes are the same and are as follows, the classes being mentioned in the order of their size.

(1) *Fair Definitions.* These include logically correct definitions. Sometimes they are not expressed definitely, but where the idea is clearly correct the definitions were given the benefit of the doubt. Examples are: "Boy,—male child;" "before man;" "the first stage of man;" "a half sized man."

(2) "*A human being*" or "a person."

(3) *Definitions based on size*, as "man, a grown up human body;" "a male being about full length." This group decreases with increasing age.

(4) *Definitions making reference to sex.* It is interesting to note the sudden increase of definitions of this sort at about thirteen years, especially with the girls, notwithstanding the fact that the fair definition group increases too. The usual form of this definition is, "a male person," or "a male." A definition given by a twelve-year-old girl

emphasizes this sex distinction as follows: "A child that is not a girl and is born from birth as a boy."

There are also smaller classes of definitions common to both words, for example, definitions according to the clothes worn, examples and sentences. All of these appear for the most part with the younger children.

The definitions of *house* and *home* are largely interchangeable. For both words the largest class is, "where you live," "where people live," and it increases with the age of the children.

A few of the other words also show interesting peculiarities when the content of their definitions is studied. Out of all the verbal expressions for *love* including when-that-and-if clauses and infinitives, nine-tenths are active in form as, "when you love somebody," "to love somebody," and kindred expressions, while only about one-tenth are passive as, "when somebody likes you," "to be loved," etc. This is certainly a remarkable showing, but is, perhaps, not an inexact picture of the relative subjective importance of the experience in the case of the normal human being. Four girls and four boys define it as "when you like each other." Definitions of *love* as specifically between the sexes were relatively infrequent, as might be expected from children of these ages.

For about three-fourths of all the children *truth* is simply "telling the truth," or "not to lie;" for one-third it is "the opposite of falsehood" or "untruthfulness." It will be remembered that the negatives for truth far outnumbered those of most other words, and these belonged to the "not to lie" or "no lie" class.

Laziness, like *love*, is defined from both the active and passive sides, as "to sit or lie around," and "a tired disagreeable feeling." The latter is by no means infrequent.

Most definitions of *life* turn on such expressions as "to be alive" or "to be living," but there are a few more definite expressions as: "when your heart is beating," "when there is breath in the body," "when you have got feeling."

With a view of comparing the definitions of the children with those of a group of adults, seventeen of the words used with the children were given also to the members of one of the psychological classes in Clark University, fourteen in all. In the case of a part of the words they were asked to note introspectively anything of importance to be observed in the framing of the required definitions.

The chief thing shown by these introspections is the great mass of associations which a word calls up. The definitions show a greater command of language and the influence of reading and of book definitions, but on the whole, were not strikingly different from those of the children. Four-fifths of the students stated that the word called up a concrete image.

The children's definitions were also compared with those of the dictionaries. The children and the dictionary makers differ in that the latter give fuller and more exhaustive definitions. Dictionary makers view a word from every aspect, while the child considers only one. This distinction may be due to the child's meagre associations, to his lack of facility in handling language and to his lack of time. Yet for the aspect which the child does define he often expresses the meaning nearly as well as, and sometimes better than, the dictionaries, though his mode of expression is often questionable from the standpoint of rhetoric and grammar.

For nouns derived from the adjective, as *happiness*, *thankfulness*, and all nouns ending in "ness," the dictionary definitions are usually such as "the state of being happy, in any sense of that word," "the

state of being thankful," etc. These are words for which adjective and infinitive definitions abound with the children. The superiority of the dictionary makers, it will be noticed, is due to little more than a greater grasp of language.

The students' definitions stand half-way between those of the children and those of the dictionaries, their definitions are longer and more fully expressed, but do not exhaust the word. Philosophical, psychological and biological definitions are the most numerous sort. Many admit that the word called up definitions they had read when studying these subjects.

LITERATURE

Essai sur les passions, par TH. RIBOT. Felix Alcan, Paris, 1907. pp. 192.

This essay completes the series on affective states, of which "La psychologie des sentiments" and "La logique des sentiments" are the earlier volumes. The book contains four chapters, the first of which discusses the question, what is a passion, the second and third the genealogy of the passions, while the fourth is devoted to an analysis of how passions terminate. The author makes no claim of offering an exhaustive treatise on the passions but rather a monographic study based on modern methods of research. He thinks that the term passion has wrongly fallen into disuse in psychology and is needed to differentiate a distinct phase of affective life which otherwise must be classified under emotion, although it differs from emotion by distinct characteristics. As a convenient mode of classification Ribot groups the affective states into three classes: (1) Affective states or feelings, properly so-called, under which he includes all agreeable or disagreeable states which express the needs and appetites inherent in our psychophysical organism, which constitute the content of our ordinary every day experience. (2) Emotions, which are characterized by a sudden onset, a break in the equilibrium of ordinary consciousness. The author defines an emotion as a sudden reaction of the egoistic instincts, motor in its nature, involving always movement or arrest of movement and characterized by intensity and brevity. (3) Passion, which is a prolonged and intellectualized emotion. The latter is primary and crude, the former is secondary and more complex. It is characterized by the presence of a fixed idea, duration and intensity. Through the fixed idea, it involves association and dissociation, creative imagination and the logical function. Everything in harmony with the fixed idea is called up by association, everything inharmonious is dropped into the background of consciousness, thus preparing the way for the imagination, which idealizes the object of passion. The chief operation of the logical function is in the judgment of values. There are two types of passions, those in which the motor (affective) element is the stronger and those in which the relation is reversed. The latter are the more enduring.

The second section, which deals with the genealogy of the passions, is prefaced by the statement that although we have numerous works under the title, Physiology of the Passions, we, nevertheless, have no physiology of passions considered as special manifestations of the affective life, since a general knowledge of the physiological conditions underlying the affective life is entirely inadequate to explain the specific and necessary conditions of individual passions. Such conditions, especially in the more intellectual passions, must, of necessity, be exceedingly complex. The author, however, considers it necessary to distinguish two levels, one corresponding to the higher and the other to the lower elements of passion; the first to unconscious or subconscious factors, and the latter to conscious states. There are three fundamental tendencies in correspondence to which all passions may be classified into three groups — those which are directly connected with the conservation of the individual, gluttony and drunk-

enness; with the preservation of the species, love; and with the tendency of the individual to self-expansion (Nietzche's will to power). The birth of a passion is conditioned by both external and internal stimuli, only the latter of which can be considered as true causes. The outer stimuli are environment, which favors the development of the germinal tendency, imitation, and suggestion, which is really a form of imitation. The internal causes are the physiological constitution of the individual, his temperament and character.

Although there are many tendencies which express needs connected with the conservation of the individual, it is only out of hunger and thirst that actual passions can develop.

The physical basis of passion tending to the preservation of the species is a purely mechanical, conscious or unconscious, attraction between two individuals, whose normal form is a synthesis of homogeneous tendencies, and therefore enduring, while those forms of love which contain heterogeneous tendencies, as, for example, jealous love, are more likely to be unstable.

The passions which are based on the tendency to expansion or "will to power" are sub-divided into those based on sympathy, those which involve conquest and those which are destructive in their nature. The first form is productive of but few passions, of which the extreme type of maternal love is the complete example, and the author devotes but a short section to its discussion.

The second group is of more importance and includes many apparently diverse passions, gambling, ambition, avarice, etc.

The third group has, as its general basis, antipathy, and comprises the destructive passions, hate, of which vengeance is the final form of expression, and the different forms of jealousy.

There is, further, a group of passions which, though not universal, do not differ in their essential characteristics from the preceding groups. These are the æsthetic, the religious and the political passions.

The basis of the æsthetic feeling, Ribot finds in the instinct of play, here following the theory of Groos. The æsthetic passion arises whenever art is recognized as an absolute good. It is, according to Ribot, stronger in the amateur and art lover than in the creative artist.

The religious passion expresses itself in both active and passive forms, the latter being represented by mysticism and asceticism, and the former by missionary zeal and fanatical persecution. At the basis of the active forms lie in the one case altruistic tendencies, sympathy with unbelievers and overflow of energy, in the other antipathy toward the unbelievers.

The political passion is based on the social instinct, and there are two types, the realistic, in which personal ambition comes into play, and the idealistic, which is less egoistic, tends toward mysticism, and the passion resembles a moral imperative.

Patriotism may also be a passion but is less complex than the political passion and may even be opposed to it though it is grounded on the social instinct.

The moral sentiment may become a passion which expresses itself in two forms, namely, by propaganda and by action.

Besides these passions there is a group which the author designates as "petites passions," but these are so characterized because of the comparative insignificance of their objects since they are often as intense as the great passions. Such are bibliomania and the various forms of the collecting passion.

The fourth and last chapter of the book is devoted to the discussion of how passions terminate.

The author gives a brief outline of the development of passions, which vary in their details, according to the nature of each passion. But all passions are of slow growth and for the most part developed before they are fully present in consciousness. Without entering into any discussion of their unconscious or subconscious growth, which, however, Ribot regards as a probable hypothesis, there are present in consciousness fragmentary tendencies, scattered and perhaps of momentary duration, which are, nevertheless, all directed toward the same end, namely, attraction or repulsion for a person, object or idea. These movements of advance or recoil follow the law of nervous excitation and are cumulative in their action so that though passions sometimes seem to arise suddenly, the suddenness is only apparent. Through the accumulation all the various tendencies and judgments of value the passion is formed and this takes place as soon as a dominant idea recognized as such is present.

A passion may terminate in five ways: (1) by weariness or satiety; (2) by transformation into another passion having a common basis; (3) by substitution; (4) by insanity; (5) by death. Since physiological processes of stimulation underlie all passions and these, according to Ribot's views, are also present even when the consciousness is not ruled by the passion, it follows that the more intense is the physiological excitement the more easily can weariness or satiety occur. The termination of a passion indicates that the physiological excitability no longer exists. This may occur in consequence of physical weakness due to illness, exhaustion or old age. Habituation is not an essential element in passion. As an accessory factor it may be indifferent, useful or harmful. In a true passion the rôle of habituation is only an apparent value. Since the stability of passion has its root in the underlying tendencies of attraction or repulsion, its persistence depends not upon the nature of the passion but on that of the individual.

A passion may terminate by transformation into another which has a common basis. This is only an apparent end and is dependent upon two conditions, a surplus of energy, which has need of expression, or the appearance of a new directive idea. The most frequent examples of this type are the transformation of human love into love of the divine or religious into political fanaticism, or a passion may change to its opposite, as love to hate. Here the fixed idea does not change but there is an inversion of its value.

The substitution of a passion in place of one totally different happens but rarely. The problem of substitution is complex and has various aspects. In some cases the dominant passion appears to depend upon age, *e. g.*, the ruling passions in infancy are the nutritive, in youth love, in adult life ambition, in old age avarice. Again, there are men of a single passion, but more frequently men of many passions either co-existent or successive, and the dominance of one of these may give an illusory appearance of substitution or among the many tendencies a true passion may arise.

A passion may end in insanity, and the question naturally arises as to whether passion itself may not be a pathological state and how the fixed idea of passion may be distinguished from that of insanity. The chief mark of distinction in the fixed idea lies in the fact that in the abnormal form the idea may be not only undesired but oppressive and repugnant, while the fixed idea of passion is desired and cherished. In general, the author concludes that there is no one characteristic by which passion may be distinguished from insanity, but each case must be considered in its entirety. Every passion may end in death. Some, like gluttony and drunkenness, carry this tendency within

themselves. Others, like the passion for gambling, adventure and ambition, may lead to it, through external circumstances.

As a whole, the book is interesting, clear in its outline, and suggestive, as are all the works of the author, yet one is left with a wish that the general relation of passion to the affective life had received a more fundamental treatment and that the rich stores of material in biography and pathology had been drawn upon more extensively.

THEODATE L. SMITH.

Der Gegenwärtige Stand der psychologischen Forschung, von PROF. DR. C. GUTBERLET in Fulda. Philosophisches Jahrbuch, 21 Band, 1 Heft, S. 1-32.

This article follows the method and outlines of an earlier article by Stumpf, entitled "Richtungen und Gegensätze in der heutigen Psychologie," thus presenting the present status of psychology in the form of its numerous oppositions and conflicting points of view. These oppositions are of different degrees and vary greatly in importance. Briefly outlined they are as follows: An opposition exists between the psychological and the antipsychological or *a priori* points of view. According to the more moderate advocates of the psychological point of view, psychology is the foundation of only the mental sciences, but according to the stricter defendants it is fundamental to all science, and all judgments which are useful for life are by continuous habituation transformed into constraining propositions, and the *a priori* reduced a mental experience. Of somewhat less importance is the question whether psychology is to be considered a natural or a mental science and in direct relation to it, the question of whether a substantial substrate of mental activity must be assumed or whether this is an extraneous question and "psychology without a soul" answers all scientific demands.

Conflicting points of view also exist between Spiritualism and Materialism and between Substantialistic and Actualistic psychology, the latter being represented, not only by Wundt and his followers, but by all opponents of the doctrine of a substantial soul.

The advocates of psychophysical parallelism stand in opposition to the adherents of the doctrine of reciprocal action of mind and body. The parallelists as actualists can admit only states of consciousness as psychological material, since only these are actual while, on the other hand, some psychologists, of whom Lipps is representative, think that psychological processes lie more below than above the threshold of consciousness, only results of activities appearing in consciousness. Prof. Freud now believes that he has found an experimental method of studying the unconscious, which can be applied to hysteria and to dreams. Gutberlet thinks, however, that the expectations raised by Freud's method may be too optimistic, especially since the question involved is connected with Herbart's "freisteigenden Vorstellungen," which are now definitely set aside. Conflicting points of view also exist between Determinism and Indeterminism, and between purely Observational and Experimental psychology. Yet Wundt himself warns against an over doing of experimental methods and denounces especially such work as that of Bühler and Marbe who have sought to investigate processes of thought and judgment through questioning subjects and demanding self-instropection. These so called "Ausfrage" experiments he declares are no experiments at all and the observers have observed nothing.

Different methods of investigation also exist in Subjective and Objective psychology, the former being limited to introspection while the latter investigates the soul life of other beings and includes com-

parative, child psychology, and abnormal psychology. Here belong, also, hypnotic investigations.

More or less opposition in view-points also exists between Descriptive and Genetic, Pure and Applied psychology. During the last two decades the applications of psychology have been numerous and it has been brought into close connection with pedagogy, psychiatry, jurisprudence, national economy, art and language, research and theology. One of the most recent sensational applications of experimental psychology is the application of the association method in the service of justice. In the October number of McClure's, Prof. Münsterberg gives an account of his experiments with the criminal Harry Orchard. Cohnstaedt has, however, raised serious objections as to the validity of results obtained by this method.

In the more modern psychology are also certain oppositions dependent upon the different directions taken by investigation. These are the oppositions between Phenomenal and Functional psychology, between Nativism and Empiricism, Atomistic and Unitary, Voluntaristic and Non-voluntaristic, Apperception and Association, Normal and Abnormal psychology. THEODATE L. SMITH.

Die Cellularphysiologische Grundlage des Gedächtnisses, von MAX VERWORN. Zeitschrift der Allgemeinbiologie, Vol. 6, 1906, pp. 118-139.

Ueber die materiellen Veranderung bei der Assoziationsbildung, von Geh. Medizinalrat PROF. DR. GOLDSCHEIDER in Berlin. Neurologisches Centralblatt, Vol. 25, 1906, pp. 146-157.

Both Verworn and Goldscheider look upon "nerve-paths," whether of memory, association, or habit, as nutritive effects of functional exercise. In nerve-cells, as well as in muscle or gland-cells, the catabolism of exercise is followed by the anabolism of rest, which not only restores the cell to its original size and strength, but increases it somewhat. Within limits, the exercise of the function creates the mass of the cell. The millions of undeveloped cells in the brain would develop if only they were sufficiently exercised.

This increase in the mass of the protoplasm in the cell results in greater instability and in a correspondingly heightened power of functional discharge. A large cell discharges more powerfully than a small one for the same reason that a large amount of gunpowder produces a greater explosion than a small amount. Because of its greater instability, the large cell has a lower threshold and is therefore more easily discharged than is a small unexercised one.

At birth the cortical cells are yet embryonic. Sensory cells are the first to be exercised by incoming stimuli. In the beginning they lack the size and strength necessary to discharge into the adjacent cells with sufficient intensity to set off the latter. Exercise confers the power to break through the cell-separation and to discharge the next cell in the chain; its discharge causes it to grow through exercise until it also has acquired the capacity to discharge a still further one in the chain; and so on indefinitely. Thus association chains are formed. The "paths" which impressions leave in the nervous system are therefore only increased growth-effects in the exercised elements. The "path" is the line of least resistance through the developed cells of low threshold and high power of discharge. The impulse once started along the line cannot run off into other previously unexercised cells because of their higher threshold and their lower power to carry forward the impulse to further cells.

These "traces" are latent for consciousness so long as the cells are at rest; but if any stimulus whatever starts the chain of discharges,

these will occur in the way the cells have been previously exercised,—the same neural series, the same mental accompaniments. Lack of exercise leads to atrophy of nerve-cells just as it leads to atrophy of any other kind of cells. Forgetting is therefore a nutritive effect; unexercised cells finally become too feeble to break through the points of cell-separation with sufficient intensity to set off the next cells in the chain and thus arouse the memory.

So far Verworn. He is indisposed to admit any factors except those nutritive ones that apply to all kinds of living cells. He regards the greater instability of the protoplasm of the developed cells as the result only of greater mass with the consequently greater tendency to break down. He admits the possibility of changed chemical structure in the exercised protoplasm, but considers it problematical and unnecessary to an explanation of the phenomena.

Goldscheider lays more emphasis upon changed molecular structure. In this connection he makes use of Verworn's *Biogenhypothese* and Ehrlich's *Seitenkettenhypothese*. He also ascribes greater importance to the fibres. He thinks those fibres and portions of fibres that are exercised will acquire greater functional instability than the unexercised ones. An incoming impulse will therefore tend to discharge along those fibre-branches that have been rendered most permeable by exercise, and to avoid those more stable non-exercised fibre-branches. He makes much of the neurone-ends where the impulse passes across from one neurone to another, regarding the protoplasmic molecules of these regions as particularly unstable. His view may be illustrated as follows:

An object presented before the eyes, for example, simultaneously arouses a number of cells in the visual area. Where a fibre from one aroused cell is in functional contact with a fibre from another aroused cell, the activity in each fibre affects the catabolic changes going on in the other, resulting in a greater chemical disintegration in each fibre than would have been the case if the other had not been active at the same time. This greater catabolism leads in the following state of rest to greater anabolism, and, consequently, greater instability in these adjacent exercised fibres than in any of the other fibres which may have been just as near but which were functionally inactive at the time. Thus are formed associative lines of least resistance through fibres simultaneously stimulated (*Knotenpunktlinie. Kraftlinienresultante*). Frequent repetition of the simultaneous stimulations accentuates the effects and renders the lines of conduction more permeable and more permanent.

In the same way fibre-lines of low resistance and high powers of influence are formed by functional exercise between dissimilar sensory areas, between these and motor areas and the like. There may be many intermediate cells and neurone tracts. The one important factor is the nutritive result all along the line of high potential energy due to mass and molecular structure, and the low threshold of both cells and fibres due to a heightened instability in the protoplasm. At first the lines will possess unequal degrees of development at different points along their course; the result will be deflections, inaccuracies and error. Practice will have a cumulative nutritive effect, producing in time a uniform permeability in all parts with attendant ease, rapidity and precision. J. F. BOBBITT.

Die Mechanik des Geisteslebens, von MAX VERWORN. Leipzig, B. G. Teubner, 1907. pp. 104.

This little book gives the practically unchanged text of a series of five popular lectures on the 'mechanics of the mental life.' Lecture

I, 'Leib und Seele,' discusses the origin of the dualistic view of mind and body, and its seeming naturalness to the average civilized man; analyses the concept of outer 'reality;' and concludes with the formulation of a sensationalistic monism. "Es existiert nur eine unendliche Mannigfaltigkeit von Inhaltsbestandteilen der Welt, die sich gegenseitig in gesetzmässiger Weise bedingen." "Die Forschungsprinzipien können in letzter Instanz auf allen Gebieten immer nur die gleichen sein. Sie bestehen allein darin, für einen Vorgang oder Zustand, den wir wahrnehmen, sämtliche Bedingungen zu ermitteln." Lecture II treats of the conditions of mental process as shown in the action of stimuli upon the nervous system; it is entitled "Die Vorgänge in den Elementen des Nervensystems." A sharp line of distinction is drawn between the function of the cell-body and that of the nerve fibre. "Der Nerv leitet keine Lähmungsvorgänge, er leitet keine Narkose, er leitet keine Hemmungsprozesse, er leitet nicht das Absterben einer Zelle, er leitet nicht die Assimilationsvorgänge, er leitet nichts anderes als einzig und allein dissimilatorische Erregungen der Zelle, die so mit einer anderen in Verbindung setzt." The seat of sensation and idea, "das Wesentliche für den Enderfolg," is without any doubt the ganglion cell. Lecture III, "Die Bewusstseinsvorgänge," traces the doctrine of cerebral localization from Gall to Flechsig; gives the neural schema for sensation and voluntary movement; interprets the association centres as "Vorstellungszentren im weitesten Sinne;" and explains memory, the process of learning, on the analogy of muscular practice. Lecture IV, 'Schlaf und Traum,' reviews in unsystematic fashion various theories of sleep, and concludes that sleep is induced by a complex of conditions,—cellular fatigue, due to the continuance of dissimilative excitation by way of the nerve-fibre, and the removal of external stimuli. Dreams are states of partial waking, conditioned upon a local excitation (by internal or external stimuli) of the cerebral cortex. Lecture V, 'Suggestion und Hypnose,' presents hypnosis as a state of extreme suggestibility, "einen echten Wachzustand, in dem prinzipiell nichts anderes geschieht, als was im normalen Wachzustande passiert,"—a state of concentrated attention upon a single point determined by the operator. The conclusion repeats the position taken up at the outset. "Materie und Psyche, Körper und Geist, Leib und Seele, existeren für uns nicht als Dualität. Es existeren nur Dinge und Vorgänge von einheitlicher Art, ganz gleich, ob sie ausserhalb unseres Ich oder in unserem Ich sich finden. Ihre Analyse kann nur immer darin bestehen, die gesamten Bedingungen zu ermittlen für die Zustände und Vorgänge, die wir beobachten."

For the style of the book we have nothing but praise; the lectures read easily, and must have been delightful hearing. The contents are less satisfactory. The crude epistemology of Lecture I may be passed over. But the cells and fibres of Lecture II show us nothing whatever of the total mechanism of the nervous system,—the very thing, one would suppose, about which a popular audience would desire information. Lecture III is psychologically inadequate; mind is made equivalent to intellect, and attention and feeling and emotion are wholly ignored. In Lecture IV Professor Verworn has not availed himself of the latest and best results with regard either to sleep or to dreaming. The lecture on hypnosis is clear and interesting, but it runs altogether on the descriptive level. On the whole, while it may be readily acknowledged that the lectures did, and that the book will, do good, it must be said that the good is much less in amount than it might have been. Psychologists must continue to write their own physiological psychology, so long as the physiologists *von Fach* make no more of it than Professor Verworn has here done.

SAMUEL T. PRIOR.

Moderne Analyse psychischer Erscheinungen, by A. HOCHE. Gustav Fisher, Jena, 1907. pp. 17.

Hoche holds that there is too much reason to agree with the late Professor Möbius in believing that all psychology is hopeless. This applies with great force to that type of psychology that is chiefly interested in the problem of the relations of the body and soul, the reality of the objective world versus its subjectivity, the problem of the freedom of the will versus necessity, the doctrine of the immortality of the human soul. To the solution of these problems we are no nearer to-day than 2,000 years ago. On the other hand, there is very great need of another type of psychology. History, religion, criminal law, medicine, education are all almost crying out for more knowledge of psychic processes. We must, therefore, now expect a period of more special and above all more objective work. This is already begun in the laboratory where conditions for introspection are observed, also in psychopathology, in the study of children and of animals, and very specially, according to this author, in retrograde amnesia. The writer believes, therefore, that the old abstract psychology is at an end and that the new psychology, which is advancing just now so rapidly in the study of split personalities and psychic degeneration, variations from type, individual psychic pathography, and suggestion, possesses the future. Especially is he impressed by the new forensic psychology's association experiments called the Tatbestandsdiagnostik.

Attention, by W. B. PILLSBURY. Swan Sonnenschein & Co., New York, 1908. pp. 346.

This really is a new edition of a volume published in 1906 in French but the author has added chapters on the measurements of attention, its relations to feeling and the self and on the educational applications of some of the conclusions. He has also expanded a short chapter in the French edition on memory, will and reason into three, while new material has been introduced here and there throughout the book. It was certainly high time to have a comprehensive treatment of the theories of attention which are, as the author well says, at present in a chaotic state. The author has sought to give all explanations in terms of observed phenomena, to show critically the relations between fact and theory, and for the sake of completeness he places special emphasis on higher mental processes than is usual in works upon attention. The general plan of the book will be sufficiently indicated from the titles of the leading chapters which are as follows — the mental effects of attention; its motor concomitants, its conditions, interest and feeling of activity; its effects in consciousness; the methods of measuring it; its relations to ideas; association in perception, memory, will or action, reason, feeling or emotion; the self, its anatomical basis, its physiology, its relation to theories of apperception; history and critique of its psychological theories; attention in pathology and in development. The last two chapters deal with the general connections and applications to education.

Vom Fühlen, Wollen und Denken. Versuch einer Theorie des Willens, von THEODOR LIPPS. Schriften der Gesellschaft für Psychologische Förschung, Heft 13 and 14 (III Sammlung). Johann Ambrosius Barth, Leipzig, 1907. pp. 275.

The writer first discusses the idea of feeling, its relations to consciousness and to objects, its quality, the feeling of activity which he deems basal, endeavor, the conditions of pleasure. He then passes to striving and its verities, treating of its general essentials, considering it as inherited tendency of apperceptions, striving of energy or interest, its conditions, and finally of active, passive and assertive striving

or endeavor. In the third chapter he considers reality striving, which is tendency, consciousness of possibility and its analysis, normal and abnormal, the relations between it and between striving and the conception of an end or object and its actualization, apperception, realization of the goal of endeavor and the antithetic relations of unity. In successive chapters he considers positive, negative and passive endeavor, the conditions and the nature of energy involved and the possibilities of effort, the differences between instinctive and conscious effort, willing and physical activity, its relations to personality, will and judgment, the logic of will, pleasure, activity and worth.

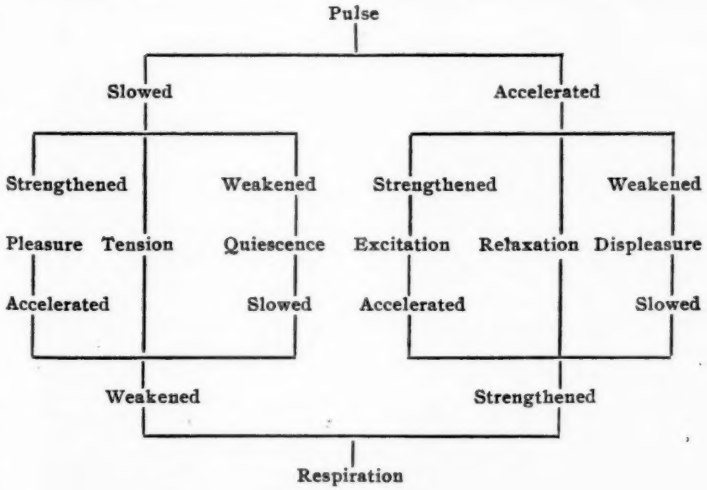
Die Grundformen der Gefühle, by N. ALECHSIEFF. (Aus dem psychologischen Laboratorium der Universität Sofia.) Mit 1 photolithogr. Tafel. Psychologische Studien, III Band, 2 und 3 Heft, 1907: 156-271.

Professor Alechsieff has performed a long series of experiments with a view to putting the various theories of feeling to an experimental test. Each experiment consisted of two parts,—an introspection by the subject and a careful measurement of the changes in the pulse-beats and the respiration by the experimenter.

His conclusions are as follows:

1. The best results can be obtained by applying both the impression and expression methods at the same time. In this way the results of introspection can be checked by the objective determination of the processes. But this plan cannot be used for the investigation of all the feelings, for many of the finer ones cannot be subjected to an objective test.

2. All psychical phenomena, which stand in no direct relation to the peripheral stimuli or the different sense organs and which are referred by us to the condition of consciousness, to the Ego, should be considered as feelings. The feeling processes are awakened by the



corresponding stimulus; they are, however, not merely connected with it; they express the changes in the condition of consciousness which arises on the entrance of the corresponding stimulus into the field of consciousness.

3. One does not meet pure and simple feeling processes. The mixed forms continually appear and the purely simple forms cannot be isolated.

4. The fundamental forms of feeling cannot be referred to two fundamental forms, such as pleasure and displeasure. They form a vast manifold and are grouped into three feeling directions, as Wundt has contended: *Lust-Unlust; Spannung-Lösung; Erregung-Beruhigung*.

5. The feelings, when they possess sufficient strength, are always accompanied by certain changes in the respiration and the pulse-beats. These changes serve as objective symptoms of the feelings. By the changes in the expression curves, six forms of feeling are determined.

6. Opposite changes in the expression curves correspond to the opposite feelings. They can be represented best by the foregoing scheme. p. 269. W. L. GARD.

The Doctrine of Primary and Secondary Elements, by DR. BORIS SIDIS, Brookline, Mass., Psychological Review, Vol. XV, Nos. 1 and 2 (January and March 1908).

Perception is treated from the standpoint of both the normal and abnormal mental life. The views of James Mill, Sully, Höffding, Taine and Wundt are objected to, on the ground that they compound perception from ideas or images. The fallacy of failing to distinguish between centrally and peripherally excited sensations is seen further in Titchener; Baldwin and James avoid this fallacy But the mistake of identifying the ideational and sensory processes is common and is to be traced back to Spinoza who made the image a weakened sensation and the sensation an intensified image. This theory is perpetuated through Hobbes, Locke, Hartley, Hume and James Mill to our times.

The author's idea with reference to the prominent and then the less conspicuous elements in perception is expounded by means of the relations of nucleus and cytoplasm in the organic cell. The slightest change in the prominent or nuclear elements brings about a considerable modification of the percept. A considerable change in the subordinate or cytoplasmic elements is needed to bring about a change in the percept. Consciousness plays with its searchlight on the nuclear sensory elements. The subordinate elements are indefinite, indistinct, in fact, may be even entirely subconscious, yet they form the main content of the percept giving it the fullness of reality. The percept is thus to be viewed as a compound whose elements are disguised and transformed by the qualitative aspect of the central elements. These central elements are, with their emotional and affective tone, the key to the situation. Biologically they are the trigger for the release of definite reactions and reveal the purposiveness of the percept.

The differentiation of the primary and secondary elements is seen in the *directness* or *indirectness* of the effects of the sensory stimuli upon the sense organs. In seeing an object other sensory elements are experienced beside the visual. These are not memory images; they have the same sensory characters as the elements given by the direct impression of the sense organs. The central sensory elements are *primary*, the subordinate are *secondary*. That these secondary elements are not ideational is seen from the differences between the ideational and perceptual. These are four: (a) A sensation has intensity, an image totally lacks it; (b) the image is a reproduction or

rather a representation of a sensation, but no sensation represents another; a sensation is an immediate experience; (c) a sensation bears the mark of externality, an image lacks it; (d) a sensation cannot be called up at will, while an image is independent of peripheral stimulation and is usually under the control of the will. Hallucinations are made up of sensory elements, while hypnotic hallucinations are made up of images. The muscular and tacto-motor sensations appearing as visual, when an object is seen, are not memory images, they are actual sensations, *secondary* sensations, giving fullness of content to the percept, having visual sensory elements as its nucleus. Pathology confirms this view. In certain mental diseases the patient can perceive but he cannot ideate. In others he can ideate but not perceive. Clinical cases point to the qualitative differences of image and sensation, irrespective of the assumption of localization. There are no memory images in perceptual consciousness although the latter may be closely associated with the ideational processes. Put briefly: "the external excitation acting in a particular sense organ produces its appropriate sensations but the peripheral physiological process diffuses, or rather to say, gets irradiated along other neurons of other sense structures, awakening their appropriate sensations. Such sensations, not being directly, but indirectly peripherally initiated should be regarded as secondary sensations." That secondary sensations are sensory and not ideational is seen from the fact that they can be produced only by a stimulus and by their own specialized peripheral physiological processes. One sensation always calls forth only a particular sensation and no other one, and that of a qualitatively different domain. "The main content of the percept consists of hallucinatory secondary sensations. Percepts and hallucinations are of the same grain. A percept is an hallucination with the primary nuclear sensory elements present; an hallucination is a real percept with the primary sensory elements absent." The dissociation of the secondary sensory elements from the primary elements causes us to regard the former as central phenomena — or as abnormal — but it is only the dissociation which is abnormal. When appearing isolated secondary sensations are the simplest form of hallucinations, which become more and more complex as the secondary elements dissociated from the primary became manifested in complex systems. Secondary sensations though present in every percept rarely appear in isolation. The affinity of secondary sensory elements to run into compounds becoming synthetized with primary elements makes it difficult to observe them except in synæsthesia and in the abnormal states of hallucination. Cases of visual and auditory hallucinations are cited. These are cases of the dissociation of the primary and secondary elements. This dissociation is often so deep and extensive that the synthetized system of secondary elements does not bear the least trace of the qualitative aspect of the primary elements; thus a morbid condition of the pharynx may give rise to an auditory and even to a visual hallucination.

The whole discussion is clear, and while perhaps in some minor points lacking in discrimination, is exceedingly suggestive, and will prove valuable in opening up some new lines of treatment.

E. E. WEAVER.

Ueberblick über die Geschichte und den gegenwärtigen Stand des psycho-physiologischen Problems der Augenbewegung, by R. HERBERTZ. Zeits. f. Psy., 1907, Vol. 46, No. 2, pp. 123-141.

This is an eminently successful attempt to present in succinct form the historical development and present status of the problem of eye-movements. The author first points out that the problem is not

merely a psycho-physiological one, but that the theoretical question as to the manner in which the phenomena of the external world become presentations in consciousness also is involved. This opportunity for emphasizing one factor or the other is the reason for the various methods of approach and the different answers given by investigators. Ophthalmologists, attacking the problem from an anatomical-physiological point of view, established such laws as those of Donders and Listing. The search for some general principle led inquiry in a physiological-mechanical direction and to Wundt's principle of simplest innervation. Helmholtz thought that the really deciding factor in the problem is to be looked for in an optical principle and encouraged research which proceeded from the psychological conception involved in Meissner's principle of orientation. Earlier investigators, however, erred in attempting to establish a law or principle of eye-movements, rather than to inquire into their import for visual perception. Only by focusing on this, and by specializing research in connection with reading, has a definite and clear answer become possible. The fact, established by Erdmann and Dodge, that visual recognition takes place exclusively during the pauses of rest, while the eye-movements, properly speaking, are interfixation movements, represents a psycho-physiological solution of the problem. It was reached by ascertaining the time necessary for single ocular movements. Volkmann, Huey, Lamanski, Dodge and Cline experimented with this point in view. Dearborn, however, who perfected the method of photographic registration, was able to show that the average time of a single movement is probably 0.02 sec. or somewhat less. This brief duration, in view of Plateau's results, naturally precludes the possibility of our distinguishing between black letters and white spaces while the eye moves.

Since the question of the function of eye-movements in reading is but a specialization of the more general problem of their function in visual perception throughout, we can almost reverse the commonly accepted theory of the past and now say: Seeing, while the eye moves, is scarcely of importance for visual recognition; whenever we really visually recognize, the eye usually is at rest. (Obviously a guarded statement which implies the belief that the last word in the matter has not as yet been spoken.) M. W. MEYERHARDT.

An Experimental Study of Visual Fixation. PROF. RAYMOND DODGE. Studies from the Psychological Laboratory of Wesleyan University, Vol. I, No. 1. Issued by the Psychological Review, as Monograph Supplement of November, 1907.

Prof. Dodge first observed the movements of the eyes during supposed fixation, with the movements of head and body to which these eye-movements are in part compensatory. The eye-movements, however, are found to be due in part to *irregular* movements of head and body, and are then disturbances of fixation for which there can be no compensation. The pulse and breathing are important factors in producing the fixation movements. Head movements may be demonstrated by watching the reflection of objects from behind as seen through smoked glasses upon cross-section paper. Satisfactory methods of recording the movements have not been worked out. The compensatory eye-movements are united with the movements of head and body "into a thoroughly organized motor system," furnishing a co-ordinating mechanism "capable of explaining the intimate correspondence between tactual and visual space." There are also visual motives for the fixation movements, in retinal fatigue and in the correction of inadequate binocular co-ordination.

Control of fixation movements involves ocular reactions, and these

are again found to be slow, but a minimum of 130σ was reached. The method of taking the reaction times and making the exposures was that of Prof. Holt, with the alternating arc light, the stimulus being given by the fall of a screen which simultaneously threw the actinic beam upon the cornea, to be reflected to the falling plate of the camera. The alternations of the current gave an approximately accurate time-record in a series of dots, and this might be made fully accurate by interrupting the direct current with a tuning fork. The arc light was "stopped down" to comfort, by plates of pot blue glass, without materially lessening the effect upon the plate.

Repeated fixations of the same word gave very different locations of the point of regard, but all are "perfect fixations" when the "object of interest is brought to a retinal area of clear vision," the functional centre of the retina varying in size with circumstances.

Prof. Dodge calls a fixation "adequate" when it is long enough and accurate enough to condition a "clearing-up" of the perception of the object of regard. He measured the time needed for the clearing-up of words exposed on various pre- and post-exposure fields such as may occur in reading, and concludes that "the shortest adequate fixation pauses in reading are between 70σ and 100σ." But words exposed peripherally, in reading for example, may modify the total consciousness without clearing up, and he investigated the effects of such factors, finding the movement to be from general to special effects, phrase, sentence, and paragraph, episode and plot forming a "dynamic background" for each new word-complex as it clears up.

The article contains a reproduction of a photographic record of the eye-movements in fast reading, taken with the alternating current. The "overshoots" of the eye, shown in the reviewer's records, are confirmed but not yet explained. The shortest fixation pause occupied 40σ.

Prof. Dodge thinks that to explain the apperception processes which condition reading we must look at the "concurrent complication of psychological processes of perception extending through several fixations." To study these he used the exposure apparatus previously described, and measured the effects of pre-fixational perception of peripherally placed words. It is unfortunate that the author does not state the distance of these stimuli from the eye, so that the peripheral angle might be known, but the effects are evident and are such as are to be expected.

Prof. Dodge fails to find experimental evidence for the traditional theory of retinal local signs, and raises the question whether the spatial relations of the total visual field are determined by its relations to the fovea, or whether the object of regard is not rather "determined in its spatial relations by its apparent position in the total visual field." He proposes a substitute theory of "genetic organization of the retinal elements" which is hardly capable of brief statement and criticism.

The appendix to the article contains a timely review of the methods and technique of recording eye-movements by photographic registration, and describes the Wesleyan apparatus.

Professor Dodge has in some way fallen into an unfortunate error as to the size of the foveal and macular fields of regard, stating these as less than one-fifth their actual size as calculated by the present writer upon the data given by Helmholtz and Köllicker. This mistaken notion of the relative sizes of the central and peripheral fields has evidently intensified somewhat the zeal of the author in some of his contentions. But the present writer's own experiments upon the effect of peripherally given stimuli corroborate Prof. Dodge's

conclusions as to the large part played by extra-foveal if not extra-macular vision, in reading at least; and probably the error has not invalidated the main contentions of the article, whose positive contribution is important, and whose author continues to show his clever originality in experiment. EDMUND B. HUEY.

Das Behalten und Vergessen bei Kindern und Erwachsenen nach experimentellen Untersuchungen, von PAUL R. RADOSSAWLJEWITSCH. Bd. I, Otto Nemnich, Leipzig, 1907. pp. 197. (Pädagogische Monographien hrsg. von E. Meumann.)

The author was a pupil of Meumann under whose direction this work was done. After giving an historical account of previous work in this field, the writer proceeds to experiments of his own; first on adults and then upon children. He finds that memory is more persistent for meaningless material than for that which has a meaning. The number of repetitions necessary both to learn and to relearn diminish with time, but the growth of practice is far greater in learning than in relearning. Even associations improve by practice as does the certainty of reproduction, provided the fidelity of the first impression remains constant. Learning and retaining are two very distinct processes of memory and have their own laws and conditions. The learning of meaningless material is of course far harder. A special practice in memory improves memory in general. As to forgetfulness, it begins very rapidly after learning and then its curve sinks more slowly. The initial loss is not nearly so rapid as Ebbinghaus thought. The types of memory differ greatly, although this seems to depend partly upon practice. The last and the first syllables of a series are least and those in the middle most forgotten. There are distinct slow and fast types of learning, although the former may by practice approach to some extent the latter, so the difference may be due to practice. Those who learn slowly retain better. It was a great help to each to follow his own type of memory with which few seem to be acquainted. All persons experimented upon were of mixed type, chiefly either visual-acoustic or acoustic-visual. Next came motor-acoustic and acoustic-motor. There was no visual-motor or motor-visual. The longer and harder task was given memory, the more sense elements were used, and only in very short series of syllables was there anything like a pure type. The impulse toward the sense of what was learned repressed the mere sensuous material. Nearly all, at first, tried to devise some logical connection between syllables; but with more practice, the more mechanical became the process. All are inclined to use rhythm and tempo, trying many at first and focusing later to a few. There was no indication that people of different nationalities preferred special rhythms. Adults exceeded children only when the work was prolonged, but adults need less repetitions. Neither showed any pure concept tpyes.

The Influence of Bodily Posture on Mental Activities, by ELMER ELLSWORTH JONES. Columbia Contributions to Philosophy and Psychology, Vol. XVI, No. 2. New York, The Science Press, October, 1907. pp. 60.

From the results of various tests in many series, the author found that the following activities were best performed in the vertical position. They are . . . the discrimination of pitch and number of taps per minute, the strength of grip. The following were best performed lying down . . . tactile discrimination, visual and auditory memory tested both by rapidity and fewness of errors and adding. The subjects showed greater signs of fatigue in the horizontal than in the vertical position.

Die Physiologische Methodik zur Erforschung der Tierpsyche, ihre Möglichkeit und ihre Anwendung, von GEORG FR. NICOLAI. Privat-dozent an der Universität, Berlin. Jour. für Psychologie und Neurologie, Oct., 1907. Band X, Heft 1 and 2. S. 1-27.

This paper describes a new method of research in comparative psychology, devised by Prof. Pawlow, Professor of Experimental Medicine in the University at St. Petersburg. The author spent three months in Pawlow's laboratory and has continued the experiments by this method.

The first point discussed by the author of this paper is the "psyche" as a concept of natural science, which he concludes is allowable, but must be strictly limited in its meaning to "the postulated ground of the actions of subjects, which is related to our subjectively felt psyche just as any form of mechanical power is related to muscle power as felt."

The conditions of method in psychology as a natural science are then enumerated. These are universality, constancy, measurability, and specificity. Any bodily function may be taken as an equivalent expresson of the psyche, but it must be independent of other influences and especially of the will. Such functions, then, as can be chosen for experimental purposes are blood pressure, pulse, respiration, separation of secretions or similar functions. Numerous experiments have been made with the first three, but the results have failed in the character of specificity. The method of Pawlow is the first to fulfill the four conditions just enumerated and he expressly states that his method is a physiological one and carefully avoids any expressions which might imply that his researches are on mental activities. The reaction chosen by Pawlow was the secretion of saliva and all his experiments were carried out on dogs. The dogs were operated upon in such a way that a salivary gland, *e. g.*, the parotid, was given an opening on the outer side of the cheek. After a few weeks this healed, leaving a permanent outlet, which appeared in no way to disturb the animal or to cause him any inconvenience, so that the reactions may be considered as normal. In order to measure the quantity of the salivary secretion, a glass tube was attached to the opening in the cheek. This very simple method gave a record of the quantity, but not of variations in the rapidity, of the secretion at different instants of the experiment, and a modification of this was, therefore, adopted, which by means of tambours, registered upon a revolving drum, so that both the rapidity and quantity of the salivary reaction were shown graphically, Saliva flows not only when anything edible is brought in contact with the mouth, but also if this is smelled or seen. The ordinary salivary reflexes from contact are practically constant and unchangeable, but under certain conditions, essentially different reflexes appear which are not constant. Pawlow had already demonstrated earlier that whenever saliva flows there is some reason to be found for it in the environment, and this in a sufficient number of cases to make it practically certain that with sufficient knowledge of the condition this reason could be found. These irregular reflexes Pawlow designated as conditioned reflexes. They differ in two points from the unconditioned reflexes: first, they may, under certain circumstances, be excited by any sense impression, and secondly, they are extremely inconstant. If something is placed in a dog's mouth, saliva will flow in all cases, but if food is only shown him or he is allowed to smell it, the salivary reflex may or may not occur. The next problem is to find out under what conditions such reflexes occur and whether they can be experimentally controlled. Although all the laws of salivary secretion are not known, certain laws of the appearance and disap-

pearance of the conditioned reflex have been established in the St. Petersburg laboratory. They are as follows: Every conditioned reflex can be destroyed by repetition. The shorter the time between its repetitions, the quicker the reflex vanishes. The destruction of a conditioned reflex in no way affects other conditioned reflexes which may be present, *e. g.*, the nullifying of a conditioned sight reflex does not affect one of smell. In cases of the vanishing of the reflex, it re-establishes itself after some hours, or, in cases of very frequent repetition, after some days. There is, however, a possibility of re-establishing it immediately by allowing it to become effectual. Thus if sight and smell reflexes to a dry meat powder have disappeared, they return as soon as the animal has been allowed to taste it.

By means of this conditioned salivary reflex a wide range of experiments becomes possible. From the nature of these experiments great care to avoid sources of error is necessary. Since anything in the environment can, under conditions, become the occasion of a conditioned reflex, it is necessary in all cases where experiments are made with conditioned reflexes to have an acute and well trained observer who is capable of distinguishing whether disturbances came from the environment or are due to voluntary or involuntary movements on his own part. Pawlow has carefully taken into consideration these sources of error and impressed upon his students the necessity of care and foresight in the manipulation of all the technique of the experiment, that the dog, which is the subject of the experiment, may not be disturbed by them.

By this method of experiment with due consideration of the possible sources of error the following results have been obtained. It is possible to decide what details of the outer world can become excitants of the dog's brain. In order to test this, any conditioned reflex may be aroused by any stimulus and the maximal change which can be made without destroying the reflex determined. When, *e. g.*, the application of cold to a certain portion of the skin the size of a dollar acts as a conditioned reflex, the saliva flows and the same result occurs when the cold is applied to another circumscribed place. This shows that the cold stimulus is a generalized one over the whole skin and that the reaction of the dog to cold is not finely graded according to the place stimulated. The same is true of heat stimulus. A totally different result is obtained if a mechanical stimulus, *e. g.*, tickling is used. When by the application of a mechanical stimulus to a specified place the reflex is aroused, it may be entirely without effect upon another portion of the skin, thus showing that the dog's reaction to tickling is more finely differentiated according to place. Hard and sharp objects are also clearly distinguished. The analytic capability of the dog's nervous system for acoustic stimuli is also great. It is comparatively easy to accustom dogs to react to a tone of special pitch and quality and not to other tones. It is then also comparatively easy to establish that the absolute hearing of dogs and their musical memory far surpasses that of most human beings. Many dogs — not all, for they vary individually as do human subjects — are able, after days, to recognize a tone which is only one-quarter a tone higher or lower than one previously associated with feeding. Furthermore, dogs also clearly hear this tone in a chord. The author by the expression 'recognizes a tone' does not mean to imply that any process of recognition takes place in the consciousness of the dog but only that different reactions follow different tones, and that, therefore, the dog must possess an organ which distinguishes tones. For instance, the dog may react to a tone associated with feeding by a secretion of ten drops of saliva, to one-quarter of a tone higher by eight drops, to one-

half of a tone higher with four drops, and to a whole tone higher with only one drop, while at a greater interval the reaction entirely vanishes. At a third or an octave he again reacts.

The method was also applied to optic stimuli and tests made of the dog's ability to discriminate form and color. A dog which six months earlier had been used for other optical experiments but had not been experimented upon in the meantime was shown several times daily, when fed, a shining white circle of about 15 cm. diameter, at a distance of 120 cm. This was continued for a month. After the association was thus established he was occasionally shown the circle without being fed, though the regular association with feeding was continued. He was also on the thirty-sixth day, without being fed, shown a square and later a pentagon. At first there was but a slight difference in the reaction to the square and the circle when shown without feeding, but gradually the reaction to the square lessened and on the fourth day practically disappeared, and the reflex to the pentagon which had been shown only twice, also disappeared at the same time. A heptagon was then used and the number of days required for the disappearance of this reflex was considerably greater than in the case of the square and pentagon. When, however, a hexagon was used there was, from the first, no reaction. In this case, the dog seemed without previous experience to refer this form to the no-food group of figures. Pawlow states that he has experimentally established by this method the capability of color discrimination in dogs. Nicolai, however, obtained only negative results in his experiments carried out in the Berlin Physiological Institute, the dogs becoming easily confused when red and green of different degrees of brightness were shown them. He would not, however, on the ground of these experiments dispute Pawlow's results, since there are numerous possibilities of error.

Other experiments have established that the analytical capability of the dog may be heightened in the case of sensations that can be measured. In these experiments temperature and mechanical stimuli were used, *e. g.*, a quick rubbing of the skin (60 strokes per minute causes a larger quantity of saliva to be secreted than a slow stroking (20 strokes per minute). This holds good not only for mechanical and temperature but also for optic and acoustic stimuli. Comparative experiments with the different senses have also been made, *e. g.*, with temperature, mechanical and optical stimuli from which it appears that the tickle stimulus is much stronger and has more significance for the dog's existence than temperature stimuli; also that mechanical are stronger than optical stimuli. Furthermore, newly introduced stimuli may have an inhibitory influence. When, for instance, a new stimulus of the same kind as one already acting is introduced there is an inhibition of the first, *e. g.*, reaction to one odor may be inhibited by the introduction of a second odor, or the introduction of a tone simultaneously with one already acting as stimulus may inhibit the reaction.

The possibility and advantages of this method are easy to discern and Pawlow has made a most important contribution to comparative psychology, for the introduction to which psychologists must be grateful to Dr. Nicolai, as the Russian reports are inaccessible to most readers.

THEODATE L. SMITH.

The Dancing Mouse, by ROBERT M. YERKES, PH. D. The Macmillan Company, New York, 1907. pp. 290.

Animal psychology is rapidly passing from the stage of chance observation to the stage of careful experimental investigation. Dr. Yerkes's book is an unusually valuable contribution, and may well

serve as a model for similar studies of other animals. The value of the book consists as much in developing and demonstrating experimental methods as in the results and conclusions reached concerning the dancing mouse. The entire work is characterized by exceptional care and accuracy in planning the tests and interpreting the results.

The first four chapters deal with the history, care, and general behavior of the dancer. "The three most clearly distinguishable forms of dance are (1), movement in circles with all the feet close together under the body, (2) movement in circles, which vary in diameter from 5 cm. to 30 cm., with the feet spread widely, and (3) movement now to the right, now to the left, in figure-eights." "There are three kinds of dancers: those which whirl almost uniformly toward the right, those which whirl just as uniformly toward the left, and those which whirl about as frequently in one direction as in the other."

The next two chapters are concerned with hearing. Previous investigators disagree as to whether the dancing mouse can hear. Yerkes shows by direct and indirect tests that adults, *i. e.*, mice more than five weeks old, are totally deaf, while some of the young give evidence of ability to hear from the 13th to the 19th day of life.

Chapters VII to XI deal with sight. The experiments on this sense are particularly valuable because of the new devices and methods employed. In regard to brightness-vision, the tests demonstrate that the dancer perceives a difference between black and white, and even between shades of gray. An attempt was then made to determine whether brightness discrimination obeyed Weber's law. Only one animal was used here whose ability to discriminate brightness differences gradually improved until a difference of one-tenth seemed distinguishable in the case of three standards of brightness. Weber's law probably holds. More data are needed, and, as the author states, the study of this problem is merely begun.

The experiments on color vision emphasize the importance of check tests and of eliminating brightness from color discrimination. "Although the dancer does not possess a color sense like ours, it probably discriminates the colors of the red end of the spectrum from those of other regions by difference in the stimulating value of light of different wave lengths, that such specific stimulating value is radically different in nature from the value of different wave lengths for the human eye, and that the red of the spectrum has a very low stimulating value for the dancer."

Chapters XII to XVI deal with the educability of the dancing mouse. The experiments were made according to three methods, the problem method, the labyrinth method, and the discrimination method. These are critically compared in regard to their merits in the investigation of various problems. The main results are that the dancer "does not learn by imitation to any considerable extent," and "that it is aided by being put through an act." Training in one form of labyrinth facilitates the learning of other labyrinths.

Chapter XVII is devoted to differences in behavior. "The race exhibits individual differences in discriminating sensitiveness to a far greater extent than do most mammals."

In the last chapter, dealing with the inheritance of forms of behavior, the conclusion is reached that there is no evidence of the inheritance of the individually acquired habit of discrimination between black and white. The experiments were carried through four generations only.

DANIEL STARCH.

Wellesley College.

The Behavior of "Roger," by ROBERT M. YERKES. The Century Magazine, Vol. LXXV, 1908, 602-608.

Mr. B. B. E. was successful in training a mongrel to perform many clever acts, an account of which appears in the same issue of *The Century*, pp. 599-602. The dog was able to spell such words as "Constantinople," "phthisic," and "pneumonia," and solve problems like "$2 \times 3 + 4 \div 2 - 1$," and "never make a mistake."

Professor Yerkes brought the trainer and the dog into the laboratory, and was able to come to the following conclusions concerning the dog's method of procedure:

1. "Simple associations of certain objects with definite acts."
2. "The habit of watching for slight movements of the eyes, head, extremities, and body of the trainer, and of making movements which experience has proved to be advantageous."
3. "The association of certain tones of the trainer's voice and certain facial expressions with definite forms of behavior, such, for example, as begging, praying, being a dead dog, and whispering."

W. L. GARD.

The Animal Mind, a text-book of psychology. By MARGARET FLOY WASHBURN. (The Animal Behaviour Series.) The Macmillan Company, New York, 1908. pp. 333.

The title of this book, the author says, should have been the animal mind as deduced from experimental evidence, for she has confined herself chiefly to the results of the experimental methods in comparative psychology. Thus, many aspects of the animal mind to the investigation of which experiment either has not yet been applied or is perhaps not adapted, are left wholly unconsidered. In this respect the book is new, for no other has yet limited itself to this field. The value of it is greatly increased by a bibliography of 476 titles, mostly, though not exclusively, limited to the scope of experimental results and methods. Chapter first is devoted to the difficulties and methods of comparative psychology. Then come the evidences of mind in the simplest animals, sensory discrimination, methods of investigation, hearing, vision, reactions and space perception, modifications of conscious processes by individual experience, the memory, idea and some aspects of attention. This work has barely a score of simple illustrations, and altogether it is almost a Godsend to the student and teacher of psychology at the present day.

An Introduction to Comparative Psychology, by C. LLOYD MORGAN. 2d rev. ed. With diagrams. (Contemporary Science Series.) Charles Scribner's Sons, New York, 1906. pp. 386.

In this book the writer sums up his own views upon the subject so well that it may be said to supersede all his previous writings. He attempts here to give them more unity and discusses a number of general psychological problems which he has not touched before. The chief topics are: — the wave of consciousness; its physiological synthesis and correlation of impressions; instinct and intelligence; the sense experience of animals; automatism and control; perception of relations by men and animals; whether the latter reason; concepts; subject; object; the evolution of consciousness; selective synthesis in evolution; the psychology of man and higher animals compared.

The Story of Insect Life, by W. PERCIVAL WESTELL. Robert Culley. London, 1907. pp. 339.

The writer deals with his facts in an interesting, informing and

orderly manner, confining himself to the commonest species of British insects and to a style intended to encourage intelligent life study of them by younger people, to discourage collecting, but to stimulate the profitable employment of eyes and ears in town or country. The insects chiefly treated are: beetles, earwigs, cockroaches, crickets, grasshoppers, dragon-flies, may-flies, lace-wing flies, ants, bees, wasps, gall-flies, butterflies, moths, bugs, frog-hoppers, gnats, crane and other flies.

Mosquito Life, by EVELYN GROESBECK MITCHELL. G. P. Putnam's Sons, New York, 1907. pp. 281.

Although very much has been written about mosquitoes in recent years, it is widely scattered through many books and periodicals, and until now there has been no single work containing in condensed form the essential facts made known concerning the different phases of this important and interesting topic. The writer first describes the systematic position and structure of the eggs, larvæ, pupæ and imago and then some adult habits, such as blood sucking, diet of males and females, hibernation, how long mosquitoes live, how far they fly, etc. Then she discusses malaria, yellow fever and other diseases. The work contains 54 illustrative diagrams.

The Life History of the Carpenter Ant, by JOHN LOSSEN PRICER. Biological Bulletin, Vol. XIV, 1908, 177-218.

Two varieties of *Camponotus herculaneus—C. pennsylvanicus*, and *C. ferrugineus*—were studied. He finds that winged forms are not produced until the colony is more than two years old. Sexually perfect individuals are not produced until the colony numbers approximately two thousand workers. It requires a colony from three to six years to reach this size. He believes that the variations in form are ontogenetic in origin and that there is no distinct soldier type. The division of labor among them is also incomplete. The ants show a decided preference for the red or longer rays and a decided dislike for the ultraviolet rays. In all probability the light is perceived through the eyes. These ants have some means of inter-communication. They can track themselves and others of the colony, but are not able to make out the direction in which the trail was first laid down. They seem to be guided by a kind of memory of the location of things and perhaps depend, as a last resort, on a sense of direction. When travelling from the nest, they usually pay very little attention to trails. They give no evidence of anything akin to reason. W. L. GARD.

Behavior of the Starfish, Asterias Forreri de Lorial, by H. JENNINGS, The University of California Publications in Zoölogy. Vol. 4, No. 2, pp. 53-185. Nineteen text figures. Nov. 26, 1907. Contributions from the Laboratory of the Marine Biological Association of San Diego.

The chief result developed by this careful paper is the demonstration of the variability, modifiability, unity and adaptiveness in the main features of the behavior of the starfish. The movements are shown to depend on the varying physiological conditions of the animal and the animal's nature, which demonstrably modify the physiological condition, and therefore the behavior are set forth in detail. Habit formation is demonstrated and discussed in full. The unity and co-ordination of much behavior is shown, with certain theories of its origin. There are also essentially new accounts of the method of locomotion. The monograph is intended to be a storehouse of objective facts for reference concerning the starfish so that the author deems it hardly practicable to make out a summary. He has provided

an admirable index. This work is now practically a thesaurus of what is known upon the subject.

La Nature et la Genèse des Instincts d' après Weismann, by E. MAIGRE. L'Année Psychologique, Vol. XIII, 1906, 230-244.

In this article Maigre has given an exposition of the theory of instincts which appears in Vol. I of Weismann's The Evolution Theory, 1904, pp. 141 *et seq.* (English Edition).

For Weismann instincts have a physiological basis in the cells and fibres of the nervous system. They vary and thus become subject to the operation of natural selection. But Maigre points out some instances where Weismann's theory fails. He cites the case of the kitten of Lawson Tait, and the skye-terrier of Hurt. He further reminds the reader that much comparative work is needed on this subject and believes that in the end we shall have to go back to protoplasm for the basis of an explanation of instinct.

W. L. GARD.

L'Inhibizione Motrice: studiata sperimentalamente negli ammalati di mente, by ETTORE PATINI. Ed. "Il Lavoro Internazionale Illustrato," Napoli, 1907. pp. 256.

This contribution to experimental psychology is dedicated to Prof. Leonardo Bianchi, with whom the author has worked. It is a comprehensive study of inhibition including a review of the various theories and the forms under which it appears as physiological, cerebral, psychic and psycho-somatic inhibition. The most interesting portion of the book, about one-half, is that devoted to the author's own experiments upon both normal and insane subjects. Libertini (1895) studied cortical inhibition in dogs by comparing the reflex reaction time of normal animals with that of dogs in which portions of the brain had been removed. He found that extirpation of the left frontal lobe diminished the time of the reflex of the fore leg, and that the same result, in a lesser degree, followed from extirpation of the occipital lobe. Fano, from similar experiments, came to the conclusion that the cerebral cortex exercises a tonic inhibitory action upon the spinal cord. Libertini also experimented on the reflex reaction time of the insane and reached the following conclusions:

In all forms of mental maladies the reflex time of arm movements is noticeably shortened.

In normal individuals this is a constant which oscillates between 83σ and 86σ. This diminishes in different forms of mental disease proportionally to the gravity of the affection and the degree of the patient's mental decadence.

In general, forms of exalted insanity show a greater reduction of reaction time than those of a depressive nature.

It is possible experimentally to reduce the latent time of the spinal reflex both in normal individuals and in the insane, the possible reduction being twice as great in the former as in the latter.

Patini's experiments differ from the preceding in the introduction of a new element and an inversion of the problem. The previous experiments have tested the influence of brain upon movement, those of Patini are directed to finding the effect of voluntary movement upon the brain and therefore upon the inhibition exerted by it upon voluntary movement.

His method of experiment was as follows: The subject was seated between two tables, upon one of which was arranged the apparatus necessary for obtaining an accurate record for the time of reflex reaction of the left arm to an electric stimulus. This consisted of a Hipp chronoscope, a Dubois-Raymond induction coil and a special inter-

rupter devised by the author. The right arm of the subject was placed at rest upon the other table with the elbow bent at an angle of 45°. In this position the muscles were contracted sufficiently to support a weight of 5 or 10 kilos, according to the strength of the subject. This position was maintained for some seconds, on an average about forty. This gave a static contraction of the right arm, *i. e.*, a contraction in which no movement takes place but the resistance of the weight is just counterbalanced. During this contraction, the time of the reflex contraction of the left arm to electric stimulus was taken. When fatigue began to set in, as was indicated by the trembling of the arm sustaining the weight, the reflex time of the left arm was again taken, and again after the release of the right arm from the weight. These results were compared with the simple reflex time without the static contraction, thus giving four series of reactions. These series were obtained from 12 normal subjects; young men from eighteen to twenty years, and from 68 subjects suffering from different forms of mental disease. In all but one subject, the reactions of the mentally diseased were shorter than those of normal subjects. In this case, a paralytic dement with progressive epileptic attacks, the reaction time was longer than in any of the normal subjects, thus showing an excess rather than a defect of inhibition. Patini's results agree with those obtained by Libertini in showing a progressive shortening of the reflex time according to the degree and form of the mental disease, but he attaches only a relative value to these results. In the reflexes of the left arm during the voluntary muscular contraction of the right, there was found to be a lengthening of the time, that is to say, the voluntary contraction had an inhibiting effect.

Fatigue increased the variations in the individual reactions. In general, the results of Patini's experiments show that the effects of voluntary contraction, of fatigue and of rest after fatigue in mentally diseased patients differ from those of normal subjects only in degree. The increase of inhibition which was shown by a lengthening of the time in the experiments involving voluntary muscular contraction, was, with the one exception already mentioned, less in insane than in normal subjects. The mean variation of the individual reaction times was, however, greater in insane subjects.

The study as a whole is an interesting contribution to the study of inhibition. THEODATE L. SMITH.

Contributo allo studio sperimentale della formula endofasica, by ETTORE PATINI. Premiata scuola tipografico dei sordomuti, Napoli, 1907. pp. 42.

This is an experimental study of internal speech, following the same lines as Lemaitre's study "Le Langage interieur des enfants," published in 1904. Patini experimented with twenty-one subjects, giving them, first, as a test of their introspective ability, a short questionnaire on the character of their mental images. He also makes use of Stricker's method of making his subjects try to pronounce mentally some word containing linguals or dentals with the mouth open and the tongue at rest. Patini's subjects were classified under five types, verbo-motor, visual-motor, auditory-motor, verbo-visual and auditory-visual. Lemaitre made a special category of the symbolic-visual, *i.e.*, of those subjects in which a word was represented by its initial letter or some symbolic object, as the word 'continues' by a chain. Patini, however, thinks that such symbolism, which he finds in eleven of his twenty-one subjects, is probably present in all cases of verbal imagination. He makes a distinction between the symbolism which accompanies the ideas of objects and that which accompanies the abstract idea of relation. The present study is concerned only with the for-

mer. The author also notes some individual peculiarities of symbolic representation, such as the representation of words by certain syllables, by initial letters of certain definite sizes, stamped characters with backgrounds of specific size and form. In two of his subjects he found the individual peculiarity, not referable to endophasia, of being unable to represent a straight line. One subject could form no mental image of a rectilinear triangle because the sides appeared persistently curved. Another subject presented the peculiarity of sometimes thinking of the words as written in large characters with accompanying representation of the movements of writing. Patini also observed among his subjects cases of what he calls multiple endophasia, *i. e.*, those who, under one set of circumstances, represented the words in one way and, under another set of circumstances, in a different form, *e. g.*, one subject who was ordinarily visual always became audito-motor when he mentally repeated poetry. This is neither the indifferent nor the mixed type of Charcot, the former of which includes such subjects as are able to regulate the type of their mental images at will, while the latter represent all verbal images in some one of the mixed types, auditory-motor, visual-motor, etc. Another interesting point which Patini notes is the frequent occurrence of a representative pseudo-chromaesthea which corresponds in the representative series to the pseudo-chomanthica of sensation. THEODATE L. SMITH.

Studien zur Hirnpathologie und Psychologie, by A. PICK. S. Karger, Berlin, 1908.

In this monograph Dr. Pick describes a case of "*nachstehender Anamnese*" which is of considerable psychological interest. The examination revealed a pronounced disturbance of memory but no loss of sensibility, or, to quote the author, the "*Sensibilitätsstörung* reduces itself to a greatly impoverished localization." For example, the reaction to the prick of a needle, while following promptly upon the sensation, was so inaccurate as to miss the stimulated spot by 20 cm.; moreover, at times the point of stimulation was not localized at all. Disturbances of orientation were most marked for the head and its parts, but not infrequently for other parts of the body also. 'Asked to indicate the right ear with the finger, the patient may respond readily, but in case of the left ear, stops to think, reaches about the table and only after repeated requests finds the ear.' At times the patient is entirely unable to localize the hands. At other times localization of an organ (the nose for example) is not effected until after the hands have been in contact with it for some time. In such a case the movement is, the author tells us, apparently entirely *automatic*. "If, while her hand is held, the patient is asked to tell where her nose is, she searches for it in the hand that is held, then, tearing her hand loose, grasps it and says, 'Now I did n't *see* it'."

Pick points out that the patient's expressions indicate an absence of visual representation of the parts to be localized. It appears, too, that the so-called automatic movements, taking place before visual imagery was developed, were accurate and apparently normal and *that the visual representations were, in such cases, developed only after the hand came in contact with the parts in question.*

Pick's explanation of these phenomena is that the image of which we normally make use in localization is an optical one; that the first beginnings of the bodily *ego* are compounded of tactile and kinæsthetic sensations, but that gradually these are translated into optical representations until at last the image (of our body) constructed from visual elements has fully taken the place of the tactual kinæsthetic; and that consequently when the visual image is wanting, localization is impossible. E. C. ROWE.

La loi des petits nombres: recherches sur le sens de l'écart probable dans les chances simples à la roulette, au trente-et-quarante, etc, en général dans les phénomenès dependant de causes purement accidentelles, suivies d'une instruction pratique pour le joueur. Par M. CHARLES HENRY. Paris, Laboratoire d'Énergétique d'Ernest Solvay, 1908. pp. xiv, 71.

The author of this monograph has set himself the task of discovering a law of small numbers: "est il possible de prévoir, à la roulette, des séquences, si fragmentaires qu'elles soient, au moins de signes d'écarts, les arrivées des événements se conformant finalment d'ailleurs à la loi des grands nombres"? He begins by showing that the appeal to the law of probabilities is hopeless. "Le caractère abstrait des principes et le caractère limité des lois de probabilités impliquent, en même temps que la vanité de tout système qui se réclamerait de la mathématique, la ruine infaillible du joueur"; "le joueur . . . ne peut puiser dans le théorème de Bernoulli, que la certitude éminemment morale de sa ruine inévitable." And if ruin is mathematically inevitable, it is, so to say, rendered more inevitable still by the conditions of the game: the occurrence of the blank, the enormous capital of the bank, and the limit of the maximum stake.

So far, all is plain sailing: Bernoulli's theorem and the law of probabilities. The author now has recourse to principles of 'energetics.' He takes, first, the law of inertia, "en vertu de laquelle tout phénomène énergétique présente une période d'établissement avant son état de régime et une période de persistance après la cessation de l'impulsion." This law may be assumed to apply to the roulette wheel,—if, that is, we may also assume the recurrence of a like starting-point, "d'un état initial périodiquement le même." And the second assumption is justified as a special case of another law of energetics, the law of periodicity, "en vertu de laquelle un très grand nombre de phénomènes physiques et biologiques, après une evolution suivant des lois complexes, mais en principe calculables, se reproduisent au bout de temps plus ou moins longs et qui est la conséquence nécessaire des périodes astronomiques."

There follows the construction of the empirical formula, gained by a conjunction of energetics and psychophysics. Chance, the author declares, is always a subjective phenomenon; "un phénomène fortuit est toujours une sensation remarquable, ou un complexe de sensations remarquable, agréables ou non, exprimable par des nombres entiers qui, la psycho-physique nous l'apprend, representent des accroissements relatifs d'énergie." We thus have the psychophysical formula to start with, and by simplification of terms and acceptance of relevant hypotheses from the sphere of energetics arrive at the empirical formula required. The reasoning in this chapter iv—"Vues théoriques"—is exceedingly condensed, and depends in large measure upon M. Henry's views of general psychophysics, published and unpublished. So far as he understands these views, the present writer finds himself in disagreement with M. Henry upon various points. A discussion would, however, carry us far beyond the limits of the monograph under consideration. It must suffice to say that the author, in his concluding chapters,—"Vérifications expérimentales" and "Importance de l'état initial,"—gives the results of the application of his formula, and is able to show, first, that he gets a good agreement between calculation and observation, and, secondly, that the neglect of the principles of energetics leads to flat disagreement. The work ends with mathematical appendices and with an "instruction pratique pour le joueur."

The author remarks in his preface: "je n'ai pas l'outrecuidance

d'estimer que le joint énergètique et psycho-physique par lequel j'ai cherché à saisir le problème soit le seul possible et je ne me dissimule pas que des développements beaucoup plus étendus seraient nécessaires." The present writer must confess that he finds M. Henry's use of the psychophysical formula arbitrary, and even somewhat fanciful. At the same time, the author appears, in principle, to have solved the problem before him; the empirical formula, as has been said, works well so far as tested, and requires for its working the basis of energetics. Whether the theory can be bettered, and bettered in such a way as to accord still more closely with practice, must remain an open question. In the meanwhile, the author is to be congratulated on an ingenious and successful piece of work. J. E. HAYLEY.

L'Etude Expérimentale de l'Intelligence et de la Volonté, by J. LARGUIER DES BANCELS. L'Année Psy. 13, 1906.

M. Des Bancels calls attention to the new and promising field of systematic introspection, controlled, minute, severe, of which some of the first results are found in Binet's *Etude Expérimentale de l'Intelligence*, 1903, and some very interesting further results in H. J. Watt's *Experimentelle Beiträge zu einer Theorie des Denkens, Archiv f. d. ges. Psy.*, IV, 1905, and N. Ach's *Ueber die Willenstätigkeit u. d. Denken*, 1905. These experimenters found that the sensory type varies in the same individual according to the nature of the operations involved, that there is such a thing as a generic image, that a word can be understood before giving rise to any representation, and that a decisive and determining direction is given to the thought by the conditions of the experiment, although this condition or *donnée* shows its presence only by the determinations that it brings about. Thus thought, in proportion as it is direction, organizing force, evades internal observation, and Lachelier is right when he says that "of thought psychologists know only the light that it sheds upon sensation."

CEPHAS GUILLET.

The Wisdom of the Wise; Three Lectures on Free-Trade and Imperialism, by W. CUNNINGHAM. Cambridge, University Press, 1906. pp. 125.

"To try to take opponents at their best seems to be a sound maxim of controversy." Dr. Cunningham, a well known advocate of tariff reform and imperial co-operation, here selects three competent opponents, and discusses the views of Mr. Haldane on economic science, of Mr. Strachey on imperial sentiment, and of Lord Rosebery on the problem of the unemployed. The lectures have all the wonted charm and persuasiveness of the writer's style; their subject-matter is, however, beyond the scope of this *Journal*. An appendix deals with religion and political life, and with the imperialism of Cromwell.

P. E. WINTER.

Laboratory Equipment for Psychological Experiments, by CHARLES HUBBARD JUDD. Vol. III of a series of text-books designed to introduce the student to the methods and principles of scientific psychology. Charles Scribner's Sons, New York, 1907. pp. 257.

The description of the exercises which the author gave in volume II of his series was of set purpose dissociated from description of apparatus in view of the fact that the same laboratory exercises may be tried with a great variety of different kinds of material aids. The presence of this apparatus is better than written descriptions, but the author holds that apparatus is itself a valuable means of education and might well be described as a part of it: but the work is especially designed for graduate students who are preparing to teach or to make

demonstrations. Much of the apparatus is relatively inexpensive and can be supplied by the mechanical departments of Yale and indeed of other laboratories. In general, the order of topics follows some natural psychological definition. Here, optical apparatus comes first, monocular and binocular vision; then come binaural, tonal, and cutaneous sensations, then tactile space, intensities of sensation, modes of recording movement, changes in circulation and consciousness, in muscular tensions, co-ordination, voluntary modifications in movement, analysis of co-ordination, abstraction and fatigue, momentary changes of attention, its scope and that of consciousness, æsthetic appreciation and complex processes.

Association des Idées chez les idiots et les imbéciles, par DR. BOULENGER et PAUL HERMANT. Gaud, Vanderhaeghen, 1906. pp. 137.

A Non Surgical Treatise on Diseases of the Prostate Gland and Adnexa, by G. W. OVERALL. Rowe Publishing Co., 1906. pp. 228.

La Démence, par DR. A. MARIE. (Bibliothèque internationale de psychologie expérimentale normal et pathologique.) Paris, Doin, 1906. pp. 492.

The Recitation, by SAMUEL HAMILTON. Philadelphia and London, J. B. Lippincott Co., 1906.

Résumé des travaux scientifiques (période décennale 1896-1906) de MLLE. I. IOTEYKO. Gand, Société Co-operative, 1906. pp. 32.

The Desirability of a Distinctive Type of Church Music, by NATHAN H. ALLEN. Holyoke Transcript Press, 1908. pp. 16.

Problem of the Relation of Intensity of Sensation to Education, by MASATSUGU TSUKAHARA. 1907. pp. 14.

Insular Geographical Primer, by DAVID GIBBS. American Book Company, New York, 1907. pp. 126.

The Carnegie Foundation for the Advancement of Teaching. Second annual report of the president and treasurer. 1907. pp. 124.

NOTES.

THE SIXTH INTERNATIONAL CONGRESS OF PSYCHOLOGY.

The sixth Congress of Psychology, in accordance with the action taken at Rome by the last Congress, will meet next year at Geneva. The Committee of Organization chosen for the purpose have fixed upon the time from the 31st of August to the 4th of September, 1909.

The undersigned, desiring that this meeting of the Congress should be as profitable as possible, have under consideration a slight modification of the customary organization. It will be recalled that our previous sessions have drawn an ever increasing attendance, with the result that the communications announced have finally attained an extravagant figure (270 at the Congress at Rome, not counting the twelve conferences of the general sessions). This plethora is not without danger to the existence of a congress. It produces veritable confusion. Since there is literally not time enough for all the speakers listed to present their ideas adequately, the presidents are constantly forced to hurry them and to suppress or shorten the discussions, with the result, too frequently, of a dull dissatisfaction and general *malaise*.

The complaints with reference to the defects of organization in our last congress have been echoed in several of the accounts of its proceedings. We shall cite as an example only an article from the official pen of Professor Ferrari, of Bologna, who in his capacity as secretary of the Congress of Rome was in a better position than any one else to notice the inconvenience of the customary procedure.

M. Ferrari, after pointing out the "decadence" of our great international sessions, expresses himself thus: "The law of life: Alter or perish, applies to the congresses of a science as complex and as incompletely differentiated as psychology. . . . The advantage of international congresses for *savants* and for the progress of science itself is not great. They continue by virtue of laws well known to psychologists; but it is just that knowledge which ought to suggest to psychologists the means of avoiding in the future an agreeable routine, and of profiting in the best way by the time and energy that they are willing to devote to these periodic reunions. . . . . The Congress of Rome showed clearly that the necessity of rejuvenating the antiquated and useless organization of international congresses is beginning to be felt. (Bull. Instit. gén. psychol., V, p. 497-8.)

We are sure that the opinion here expressed by M. Ferrari agrees with the feelings of the immense majority of the psychologists who have attended our later congresses.

We seem forced, then, to take new measures in the interest of the institution whose fate for the moment has been placed in our hands. But what reforms shall be offered for this state of things which everybody laments?

Without wishing to settle anything definitely at the present time, we desire to indicate briefly the direction in which we believe that it is necessary to turn in this matter, hoping that this will lead our colleagues in all lands to consider the matter from their points of view and to communicate to us the ideas at which they may arrive with reference to a possibly improved organization of the next congress.

1. Since to-day scientific periodicals are numerous and offer the greatest facilities for publication of all work of value, the true purpose of an international congress should no longer be the reading of innumerable isolated communications upon extremely diverse subjects—necessarily abbreviated and hasty, but should rather be that of allowing a somewhat thorough study and discussion of a limited selection of particularly interesting or vital questions. Our first desire is, then, to place upon the programme of the congress certain *questions of present importance* upon which reports and counter reports should be presented, which latter should also be published beforehand so that those who intend to take part in the Congress may be able to prepare their objections or their communications upon these themes of discussion.

2. We would like in particular to devote some sessions of the Congress of Geneva to the question of *psychological terminology* with regard to which the Congress of Paris, in 1900, expressed the hope that it might be taken up at the next session. Our purpose is to lay before the Congress a plan of terminological equivalents in our chief languages with a view to fixing a certain number of daily more indispensable technical terms having reference to experimentation and perhaps also to certain psychical phenomena or processes. This is, of course, an arduous undertaking and one upon which the coming congress can merely make a beginning.

3. We desire finally to arrange an *exposition of apparatus*, as has already been done at previous congresses. But we would like to have more time reserved for the examination and demonstration of the

apparatus; for this sort of communication can be made only with difficulty and very imperfectly by means of printed memoirs, but is admirably adapted to the function of a congress.

We shall be very grateful to all our colleagues who are willing to do so, if they will send to us as soon as possible their observations upon the points which we have mentioned, suggest to us still other innovations and make proposals as to the choice of subjects to be placed for discussion on the programme of the next congress.

Committee for the Sixth Congress,
TH. FLOURNOY, *President*,
P. LADAME, *Vice-President*,
ED. CLAPARÈDE, *General Secretary*,
Champel, 11, Geneva.

FIFTH ANNUAL MEETING OF EXPERIMENTAL PSYCHOLOGISTS

The fifth annual meeting of Experimental Psychologists was held in the new psychological laboratory of Harvard University in Emerson Hall April 15-17. The following laboratories were represented: Brown (Delabarre), Bryn Mawr (Ferree), Clark (Sanford and Porter), Columbia (Cattell and Thorndike), Cornell (Titchener), Johns Hopkins (Baldwin), McLean Hospital (Wells), Pennsylvania (Urban), Princeton (Warren and Vaughan), Smith (Pierce), University of New York (Lough), Wesleyan (Dodge), Wellesley (Starch), Yale (Angier and Cameron). Communications were presented by Pierce on the Checker Board illusion; by Lough on Some Applications of Tests of the estimation of Distance by the Eye; by Dodge on Types of Pursuit Movements of the Eyes in Cases of Mental Derangement; by Urban on the Psychophysical Methods; by Holt on the Technical Installation of the Harvard Laboratory. An interesting discussion on the place of Laboratory Tests and Demonstration Experiments in Elementary Courses was introduced by Warren. The equipment of the laboratory and the investigations in progress at Harvard were demonstrated and explained by Professors Münsterberg, Holt and Yerkes with the assistance of graduate students in the department; informal reports of current work in other laboratories were also made. The visiting psychologists were hospitably entertained by Professor Münsterberg and his colleagues. It was decided, on the invitation of Professor Warren, to hold the next meeting in the laboratory of Princeton University.